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FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

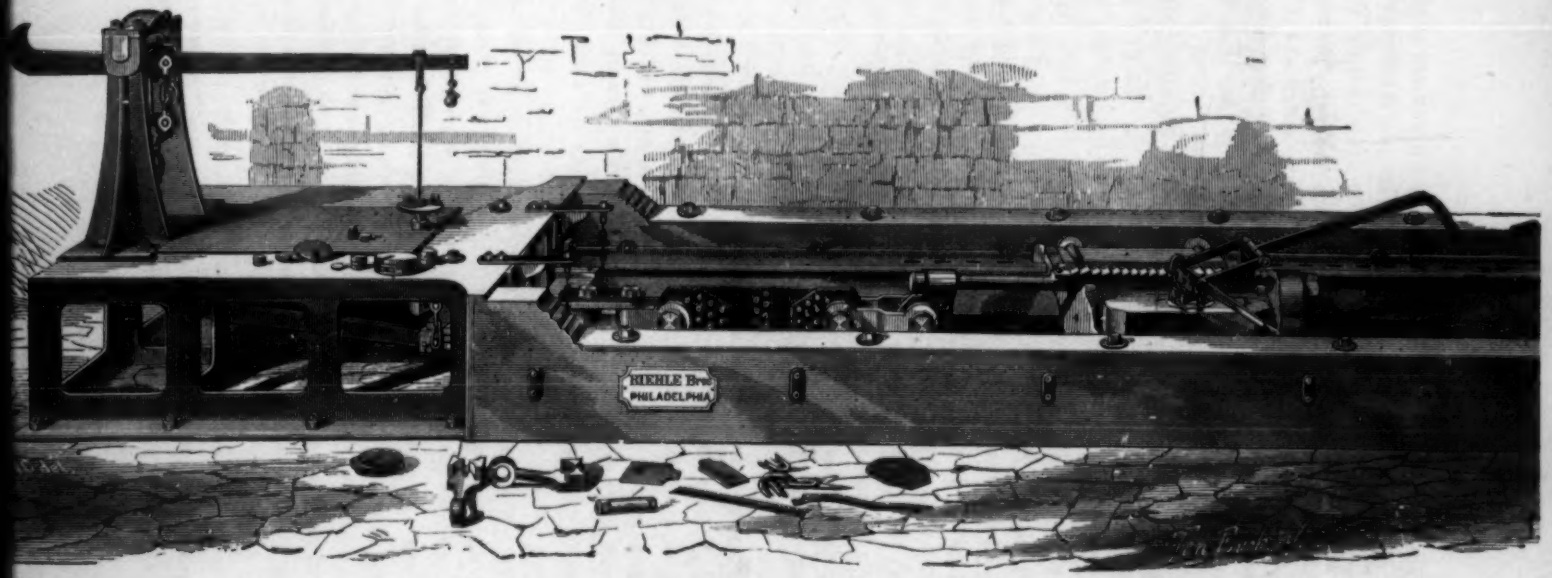
ITEMS AND NOVELTIES.

A New Testing Machine.—The accompanying engraving represents a new form of horizontal testing machine, of 75 tons capacity, built by Riehle Bros., Philadelphia, and designed by T. Alsen, Superintendent.

At one end, enclosed in an iron frame, is a heavy intermediate lever, one fulcrum of which (the upper one) bears against a plain steel surface composing a part of the iron frame, accurately and firmly inserted, the lower fulcrum presses against the clevis that connects directly with the tools that hold one end of the test specimens. This intermediate lever is suspended at the larger end by clevises that swing from the iron frame, and at the smaller end from a compound parallel crane beam that rests upon pedestals. Upon this parallel beam you will observe an ordinary weight-dish, upon which U. S. standard weights are placed to weigh the strain that the test piece is being subjected to; one pound on the weight-dish indicates a strain of one thousand pounds on the test specimen. At the other end of this machine is used a hydraulic jack and pump, which is placed upon low, strong wheels, and run along a railway and stopped at any desired

point by means of keys dropped into slots in the railway about ten inches apart; this is in order to accommodate the length of the test piece, which might be but a few inches, and can be a hundred feet long or more. The power is applied merely to take up the slack, the strain is weighed and even broken by the weights being placed upon the weight-dish on crane beam, which must be kept parallel by the use of the power and weights together. The equipoise of the beam is indicated by means of a finger point that must vibrate free when the proper weight is applied; this is clearly shown in the plate, between the pedestals. When the test piece is in position the lever and beam must be balanced by means of the balance cup hanging from extreme end of parallel beam. All the bearings and fulcrums are steel, made very strong and true, and as each part swings perfectly plumb, there is no friction, and a strain upon a specimen can be weighed to within a few pounds. The operation of the jack and pump is as follows: the handle of the pump being operated, the plunger of the jack is forced out horizontally, and is connected with the tools that are fastened to a cross head by means of two bolts. In order to get the plunger back again a lever is used that, being raised, catches in a ratchet, and when pressed down forces it back again; this operation also sends the fluid back from the jack into the pump reservoir. The iron frame and the timbers that support the iron guides are all firmly secured to a foundation of masonry. This machine is represented straining a piece of double riveted boiler plate (with ten rivets) in order to ascertain the comparative merits of steel and wrought-iron plates, also single and double rivets, with drilled and punched holes. It was built for E. B. Ward, Esq., Detroit, for the purpose of testing chain, wire and hemp ropes, also bridge bolts and boiler plate, and is ninety feet long when put up for use; but the construction of the machine embodies certain principles that can be modified indefinitely, and adjusted to apply any desired strain, to any material, in any shape or form—including the crushing resistance of iron or stone columns, transverse strain of girders, and torsional strain.

Rolling Molten Steel.—Our mechanical contemporaries have been commenting on a method recently invented by Mr. James Robinson, of Glasgow, for treating and shaping metals as they are poured in a molten state from a Bessemer converter or other vessel. The fluid mass is received between a set of rolls so placed as to retain the liquid metal until it becomes sufficiently chilled to be handled. The



RIEHLE BROS. TESTING MACHINE.

rolls at the receiving end are conically shaped, so that the iron is gradually compressed and a delivering action set up in the mass of iron as it passes between and longitudinally along the face of the rolls.

The advantages to be derived from a process with this object successfully accomplished would be numerous and noteworthy; but many difficulties are involved in the realization of the problem, chief amongst which consists in the necessity of keeping the rolls sufficiently cool as to prevent them from being warped by heat and pressure when working in direct and continued contact with a mass of metal at a temperature of about 2000° F. To obviate this difficulty the inventor proposes to cool the rolls, both internally and externally, by suitable methods.

Should the plan prove to realize the problem successfully, there will be nothing to prevent the production of steel bars of unlimited length directly from the converter, and at a considerably reduced price in view of the saving in cost of production from the avoidance of reheating for subsequent rolling; and it promises, in that case, to take the position of a radical innovation.

Improved Radial Drilling Machine.—The advantages of the radial drilling machine over the ordinary drill press, are becoming more fully understood and appreciated, and in the best machine-shop practice, it is acknowledged to be preferable to use the former on all work, no matter how small, while on work of any size, or which has several holes to be drilled in it, there is no question as to its great superiority. Heretofore, these machines have been used almost exclusively for drilling large work on the floor, and have not been adapted to work usually done on the ordinary drill press. Messrs. Thorne, De Haven & Co., of this city, have designed and are manufacturing a drilling machine, which possesses all the features of the most approved stationary machines, combined with the advantages of the radial machine.

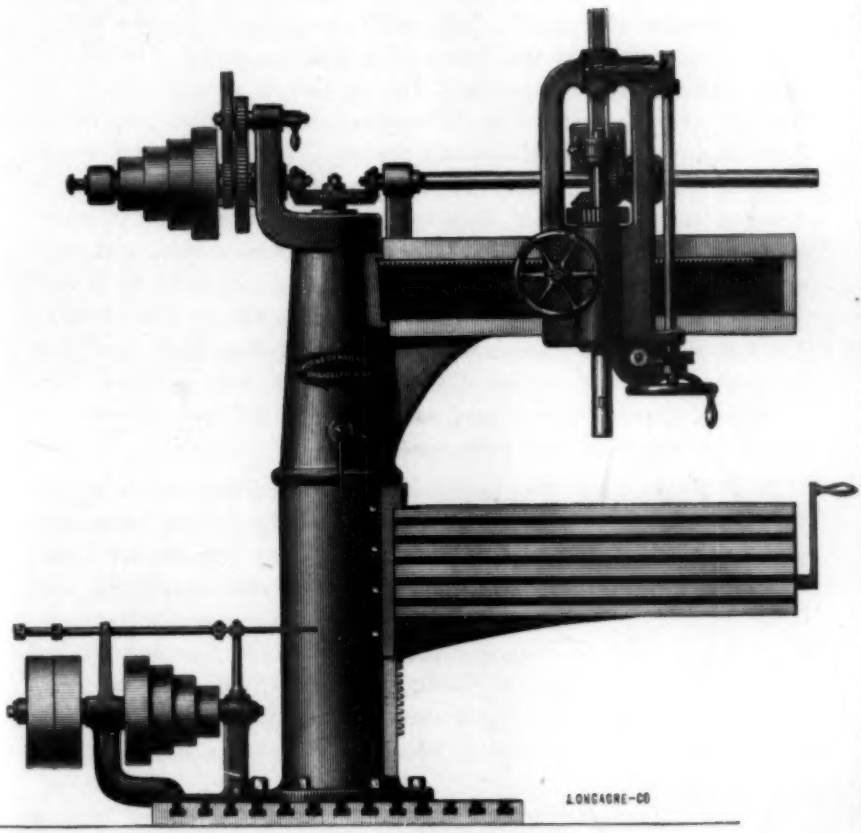
The counter-shaft is on the base-plate, and the driving cone-pulley and back-gearing on top of the post, thus placing the belt-shifter in a convenient position, and enabling the changes of speed to be made quickly. The bevel-gearing on top of the post permits the arm to rotate through an arc of 320 degrees, or eight-ninths of a revolution. The cone has four steps, which, with the back-gearing, gives eight changes of speed. The table has T slots on top and side, and

is raised and lowered on the post by a rack and pinion, operated by a tangent-wheel and worm. This enables the top of the piece to be kept at the same height. When the work is too high to go on the table at its lowest position, the base-plate which projects from the front of the machine can be used. The table being gibbed to the post, reduces the leverage, and makes a much stronger and stiffer arrangement than where it is set on a base-plate to depend for stiffness on a thin section of metal. The saddle carrying the spindle is travelled in and out on the arm by a rack and pinion operated by a hand-wheel in a convenient position. The spindle is counterbalanced by a weight, which is carried by the saddle—this being the only Radial Drill in the world which has this feature. As the counter-weight takes directly on the spindle, it prevents the latter from dropping, in event of any lost motion. This overcomes a fruitful cause of breaking drills; namely, when the drill drops into a blow-hole, or through a drilled hole before it is finished. The feed is obtained by a rack and pinion, operated by a worm and tangent-wheel—thus reducing the lost motion to a minimum. The self-acting feed has three speeds, and is connected and disconnected by a friction-clutch, operated in the centre of the hand-wheel. The hand-feed is quick, to enable the spindle to be run up speedily.

The Baltimore Tunnels.—The local journals recently contained an account of the two miles of tunnelling that is being constructed under the streets of Baltimore. The tunnels are broad enough to admit of the passage of two trains, with considerable leeway. The Potomac Railroad Tunnel, which is to unite the Baltimore and Potomac and the Western Maryland with the Northern Central Railroad, will be completed in all probability by the first of May. The Union Tunnel, which will connect the Philadelphia road with these, is also hastening to completion, and promises also to be finished by the same time.

The Southern bound passenger from the North will then, instead of going down to the President street depot, turn into the Union line, plunge underground at Bond street, on through the Union Tunnel, and out again into daylight, along the Jones' Falls valley up to the Northern Avenue Bridge, underground again, on out to Gilmer street, and thence southward along the Baltimore and Potomac line, having done in all a little more than two miles underground.

The Diagraph.—We have received from Messrs. Darling, Brown



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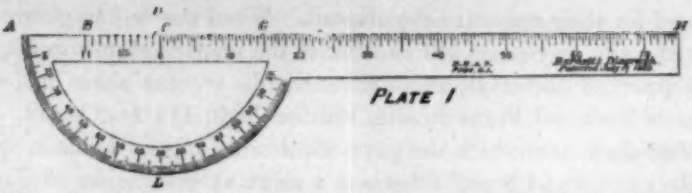
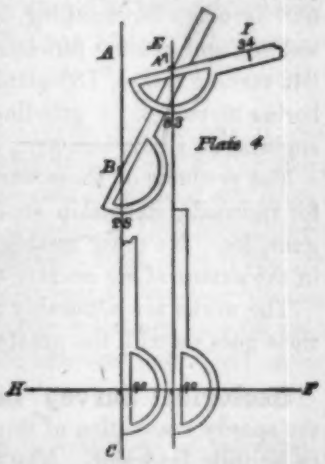


PLATE I

& Sharp, Providence, R. I., the description of an instrument to which they attach the above name, and for which they claim certain advantages. It is designed to substitute the ordinary box of surveyor's instruments, and the work of drawing diagrams and platting surveys is claimed to be greatly shortened by its use; and only requires the addition of compasses for circles to perform the work of the ordinary instruments with accuracy and facility.

The advantage of the instrument appears to be that it gives at one adjustment both the direction and the length of a given line. It consists of a slim circular protractor, A L G; four inches in diameter, graduated in degrees; of the rule A G H, the extension of the diameter A G, graduated into 10ths of an inch (and subdivided to show 20ths), a vernier C B, and a small nib or protection D. To most of our readers, who are familiar with the use of mathematical instruments, the use of the Diagraph will be obvious from an inspection of the engraving showing it. Figs. 2 and 4 are added to show its use respectively in drawing a line of desired length and angle, intersecting another, and in working up surveys from field notes.



East River Bridge.*—The work of preparing the grounds for the anchorage of the East River Bridge in James street, between Front and York streets, Brooklyn side, is progressing rapidly. A week ago the demolition of the thirteen buildings which occupied the ground required, was begun, and from present appearances it seems likely that the last stone will be taken away before the twenty days

* Chicago R. R. Review, Feb., 1873.

allowed for their removal have elapsed. When the buildings are all cleared away, guy-posts will be sunk to the number of ten in all, for the support of the stays, and a tower will be erected about mid-way between York and Front streets, 100 feet high, 114 feet broad, and 100 feet deep, over which the guys, which will support the main span, will be carried and brought down to a point at the corner of James and York streets, where they will be secured to bolts sunk in enormous anchor plates. Several other structures will be erected at intervals for the support of the Brooklyn side of the bridge, but there will be no other tower between the one on James street and the main tower at the river. It is probable the construction of the tower will be entered upon within two weeks.

Krupp's Establishment at Essen.*—In these gigantic workshops there were manufactured during the last year 150,000,000 lbs. of cast steel. In the year 1870 the product was 130,000,000 lbs. In this immense establishment 8810 workmen are employed, and engines with a total power of 9,595 H. P. are in requisition to operate the machinery. Amongst the various details of the works are included 528 furnaces for smelting, heating and converting, 169 forges, 260 welding and heating furnaces, 245 coke furnaces, 130 other furnaces, 342 turning lathes, 130 planing machines, 73 cutting machines, 172 boring machines, 94 grinding benches, 174 steam-boilers, 265 steam-engines, 58 steam-hammers, and 209 various other machines.

The products of these works consist of axles, wheels, rails, springs for railroads, steamship shafts, boiler plates, rollers, tool steel, rifled guns, &c. No other establishment in the world may compare with it in the extent of its operations.

The works are admirably managed, and the daily routine of operations goes on with the greatest regularity and precision.

Geological Survey in Pennsylvania.—The prospects for the speedy realization of this highly important work seems at present to be quite favorable. The fact that Pennsylvania, of all other States in the Union, more directly interested in securing a thorough and scientific knowledge of the character, extent and limits of her mineral resources—so intimately related to the prosperity of her vast mining and manufacturing industries—is not provided with a standing Geological Bureau, is an anomaly, which, in these days when the practical

* Am. Exch. and Review, xxii, 304.

value of scientific research is universally conceded, is anything but flattering to the profundity of her legislators.

Upon another page of the *Journal* will be found a letter written by Prof. Lesley, to the Governor of the State, in response to his request, in which will be found a lucid statement of the necessity and the value of such a survey, and also a plan for systematically conducting its operations.

At the last meeting of the Franklin Institute, the following resolution in reference to this important work was unanimously adopted:

Resolved, That the Franklin Institute heartily approves of the suggestions made by Prof. Lesley in his communication urging the establishment of a Geological Survey of the State of Pennsylvania, and fully appreciates the necessity and value of such a survey in advancing her material interests.

A Large Rolling-Mill.—The great rolling-mill at Bethlehem, Pa., now in process of completion, is stated, upon good authority,* to be the largest in the world. The main mill is 936 feet long, and 111 feet wide, the wings forming a cross 348 feet long. The whole structure is built, in the most substantial manner, of stone, iron and slate. The boilers are located outside the main works, the stacks being built of the most solid iron, riveted. They are 14 feet in diameter at the base, and are about 120 feet high.

Railway Speed in England.†—The average rate of speed on nine of the principal lines terminating at London, is 47¼ miles per hour. A train on the Great Western runs 76 miles at the rate of 53¼ miles per hour. The journey from London to Bath over this road is the quickest in the world. The distance is 106¾ miles; the train is timed for 2 hours and 13 minutes, including 10 minutes stoppage at Swindon; which makes the running time something over 53 miles per hour. The fastest time on the Great Eastern line is 41 miles per hour.

Utilization of Furnace Slag.—A method of utilizing blast furnace slag, so as to render it suitable for such purposes as ballasting for railways, &c., on the following plan, has been for some time in operation at the George-Marien furnaces, at Osnabrück, in Hanover, viz.: It is allowed to flow from a height of eight feet into water, the effect of which is to convert it into a pebbly condition. As rapidly

* Iron Age, Feb., 1873.

† Chicago Railway Review, Feb., 1873.

as this is formed it is taken from the water by means of an endless chain of buckets, which load it directly on the railway trucks.

Purifying Irons.—Experiments made with pig irons of poor quality at Thale-in-the-Hartz, by puddling them in contact with a small ($1\frac{1}{2}$) per ct. of fluor spar, with the view of removing the phosphorus therein contained, are stated to have been very successful. The product is stated to have been the production of a fibrous bar iron, not at all coldshort—a result which was somewhat remarkable, since the pig iron employed (Ilseder) is known to be amongst the poorest brands of German irons, containing a notable proportion of phosphorus.

Coal in China.—The presence of enormous coal beds in China seems to have been proven, by Richthofen and others, beyond doubt, and affords an interesting field for speculation as to the influence which possession of this civilizer must sooner or later exercise upon the future destiny of this exclusive nation.

According to the most accurate estimates thus far pronounced, the Chinese coal fields extend over an area of 400,000 square miles. In the province of Hunan there is a coal field of 21,000 square miles; consisting of two distinct beds, one of them being bituminous and the other anthracite. The last named of these is readily available, conveniently located for transportation by water, and equals in area the anthracite fields of Pennsylvania. In quality it is stated to compare favorably with the best anthracite known. Another province (Shausi), the coal area reaches the enormous figure of 31,000 square miles, and at the present rate of consumption could itself supply the world for thousands of years. The veins are from 12 to 30 feet in thickness, and are most favorably located for mining. Besides these highly favorable natural facilities, the province is stated to possess, in immediate proximity to the coal beds, exhaustless supplies of iron ore.

Experiments on Building Materials.—Some interesting experiments upon the influence which the acids existing in the atmospheres of cities exert upon building stone of various kinds, have been recently made by Dr. Angus Smith. This deteriorating influence was found to be particularly noticeable in cities using bituminous coal largely for domestic and industrial purposes. It was found that even the most siliceous stone was seriously affected.

The experiments were suggested by an observation of the rapid

decay of these materials as displayed in many English cities. The obvious inference as to its cause being that it was due to the action of the acids absorbed in the rain-water, the author was led to test the behavior of a number of samples towards acids, with the following results:

Blocks of various stones, of the size of one cubic inch, were broken by permitting a hammer to fall upon them from a given distance, and recording the number of blows required to produce fraction.

The same material was next steeped for awhile in diluted sulphuric acid, and subjected then to the same test; the result being that some of the specimens gave way at once, while others withstood the test with varying degrees of deterioration from the original quality.

These experiments are only the beginning of a series on the subject, and they promise to furnish quite a valuable contribution to our knowledge.

A Stationary Ship Saloon.—The attention attracted by the proposition of Mr. Bessemer to relieve the cabins of steamships entirly from the rolling movement of the vessel by suspending the same upon a pivot, is doubtless familiar to all the readers of the Journal. This design of Mr. Bessemer's has now, however, a rival in a proposition for a floating cabin devised by Mr. Alexandrovski.

The construction is similar to that of Mr. B., but the cabin, instead of being attached to a pivot, floats in a kind of tank placed amidships, between the engines.

The invention has been tested in practice by the head of the Russian Naval Department, and is reported to have proved entirely satisfactory—all efforts to shake the cabin having proved fruitless—and the rolling motion of the vessel being completely counteracted.

The Waste of Fuel.—At a recent meeting of the English Institute of Mechanical Engineers, the President, Mr. Siemens, made the statement that from one-half to two-thirds of the coal mined in England was wasted or destroyed carelessly; and that, theoretically, the fuel consumed possesses more than ten times the capacity for iron-making or steam generation than is now realized from it in practice. In explanation of his remarks he further stated that sixty-eight pounds of coal is theoretically enough to bring a ton of iron to the welding heat, and more than enough to melt the same weight of cast-iron; while the actual amount consumed varied from ten to twelve,

and at times to thirty times as much, and in some instances to even more.

But, to prove that much better results are within realization, he added that within the last nine years the consumption of coal per indicated horse-power has been reduced to one-half in the marine engine, and that if the average marine engine consumption of nine years ago is compared with the best results attained at present, the improvement is still more striking; for nine years ago the average consumption of coal per hour per indicated horse-power was 4·5 pounds. Steamships now make long voyages with a consumption not exceeding 2·2 pounds, and more rarely 1·7 pound of coal for the same duty.

Prize for Steel.—The Council of the Society of Arts has resolved to award the gold medal of the Society to the manufacturer who shall produce and send to the London International Exhibition of 1873, the best collection of specimens of steel, suitable for general engineering purposes. The following conditions are stipulated.

(*a*). The specimens exhibited for competition must include a complete illustration of the applications of the varieties of steel submitted.

(*b*). Each manufacturer should send with his specimens a statement of the nature of the tests he has applied to each kind of steel exhibited, and give the results of such tests.

(*c*). The samples tested are to be exhibited together with duplicate samples, or portions of the same samples, in order that they may be submitted to the same tests, should the Council deem it desirable.

(*d*). The Council reserve to themselves the right of withholding the premium in the event of the specimens exhibited not being sufficiently meritorious.

The Tin Discoveries.—In the last number of the Journal there was published a brief statement of the fact that extensive deposits of tin ore had been found in Queensland, and since that time a substantiation of the announcement has been made in the form of a report from Mr. T. V. Gregory, the mineral land commissioner of the Colony, which, besides giving much definite information as to the extent of the tin fields, places the value of the reputed discoveries beyond doubt.

From the report in question, we gather that the extent of territory upon which tin has been actually discovered, comprises about 550 square miles. Of this area, however, only about 220 square miles have been found to contain tin in sufficient quantity to pay for work-

ing. The country, in its geological and physical features, is an elevated table land, intersected by numerous abrupt hills. This country is traversed by numerous streams, of which the Severn and its tributaries are of especial interest in this connection, since it is on the course of this river that the greatest portion of the mineral wealth has been found. The richest deposits of ore have been found in the stream beds and fluviatile flats bordering upon them; the payable ground varying from a few yards to five chains in width, occasionally broken by rocky bars; but even in these instances, large deposits are frequently lodged in the pockets and crevices between the granite boulders. The probable yield of ore from the alluvial workings alone is estimated by Mr. Gregory at about ten tons per lineal chain of the creek beds, though in some instances it will be considerably greater than this.

Of the existence of veins or lodes the report also gives assurance that several of considerable size have been located and claimed; though of the probable value of these as sources of future wealth, when the alluvial deposits have been exhausted, the author does not venture an opinion.

The reported tin discoveries in Queensland may therefore be set down as fully authenticated, and we may shortly look for brisk competition in the production and export of the metal derived from the colony.

Improvement in Bending Glass Tubes.—If the glass tube we desire to bend be filled with *sand*, and each end stopped to prevent its escape on heating over a Bunsen burner, it will be found that the tube may be quite doubled if desired, a perfect curve being produced. In this way we may promptly produce accurate bends of any desired size in tubes of any bore without any previous skill in glass-working. Obviously, the principle depends on a uniform distribution by the sand of the pressure exerted. A similar plan is resorted to by metal-workers in bending tubes of lead. A. H. GALLATIN.

Laboratory Cooper Union.

Comparative Value of Explosives.—The universal employment of explosive agents in engineering operations, which in these times have assumed a magnitude heretofore undreamed of, has made it a matter of much practical interest and importance to determine the relative value of the various materials employed for that purpose. Perhaps the most reliable experiments in this field are those of Prof.

Abel, who, in order to determine this question, made use of the opportunity to test the relative value of gunpowder, gun-cotton and dynamite, in driving a railway tunnel through limestone rock, the conditions of their employment being (as near as such a thing is possible in practice) equal for the three explosives tested.

The results of the comparative trials are stated as follows:

In one week the tunnel was driven eight yards with gunpowder, fourteen yards with gun-cotton and fifteen yards with dynamite, the weight of the explosives employed being—of gunpowder 756 pounds, of gun-cotton 169 pounds and of dynamite 165 pounds. The number of blast-holes per yard was—gunpowder 31, gun-cotton 18 and dynamite 17, and the cost was—gunpowder $142, gun-cotton $83 and dynamite $77.

In commenting upon these results, so favorable for the dynamite, several of our scientific contemporaries express themselves with some severity in regard to the shortsightedness of the legislation by which the manufacture, sale and transportation of this material is surrounded; since it has proven itself to be, in practice at least, as safe as gun-cotton, and considerably more efficient as an explosive.

A New Experiment.—Mr. Elihu Thompson has made the observation that tin-foil, if wrapped about a few crystals of chlorate of potassa, can be made to detonate loudly upon being struck smartly with a hammer upon an anvil, or in a mortar. The phenomenon being precisely analogous to the well-known experiment of triturating sulphur and the chlorate. To the best of our knowledge, the observation that such metals as tin can be oxidized in this way, is a new one and worthy of notice.

Soluble Glass in the Arts.—The employment of this substance in the arts is rapidly extending, and it has become indispensable in many industrial branches. It seems to be specially well adapted to the production of cements. When intimately mixed with fine chalk, it is found that a hard cement will be formed in from six to eight hours. With powdered sulphide of antimony, a black mass is produced which is susceptible of taking a high polish, and possesses then a superb metallic lustre. Fine iron dust gives a grey-black mass of great hardness. Zinc dust gives a grey mass of much hardness, and having a metallic lustre. Zinc castings can be readily repaired by its aid.

Concerning Glycerin.—The manufacture of this important substance has of late, in view of its constantly extending importance in the arts, been greatly expanded. During the past year the production in this country reached 2,000,000 of pounds, of which one firm in Cincinnati manufactured one-half of this quantity. Upon the same subject, it may not be uninteresting to note that, in a communication addressed to the French Society of Civil Engineers, M. Austin has highly recommended the employment of this substance as an anti-incrustator in steam-boilers. Glycerin, which is soluble, in all proportions, in water, appears, according to M. Austin, to increase very notably the solubility of the lime salts, to which the evils of incrustations in boilers are mainly ascribable; indeed, according to the author, it really forms with them a soluble compound. When the lime salts accumulate to such an extent as to be no longer soluble in the glycerin present, they are deposited in the form of a gelatinous sediment, which does not adhere to the boiler surface. M. Austin recommends the employment of one pound of glycerin to every 300 or 400 pounds of coal burnt. From actual trials made with the material, it is declared in the communication that the employment of glycerin for this purpose, and in the manner above described, proved successful.

Fusion of Platinum.—M. Violette communicates the fact that he has succeeded in fusing platinum. The draught of the furnace employed was very powerful, and the Hessian crucibles employed for the purpose, though lined with plumbago, were partially fused. The results of the experiments are stated as follows: In a crucible of this kind, 50 grms. of platinum were placed, partly spongy and partly in fragments; and after an hour's stay in the furnace the crucible was withdrawn, and at the bottom there was found a perfectly melted button of platinum of the same weight.

Stalactitic Gelatinous Silica.—In experimenting at the Central High School with silicate of soda solution, it was found that when such solution is placed in a small porcelain capsule or other suitable vessel, and to it is added about an equal volume of concentrated sulphuric acid, taking care not to add it too suddenly, the silica deposited prevents the thorough mixing of the acid and silicate.

If, now, the vessel be inclined so as to allow the liquids to run as a stream from the vessel, the deposition of the silica takes place in the form of an icicle or stalactite depending from the lip of the capsule.

On close examination, it is found that the acid runs upon the outside of the stalactite, whilst the silicate flows down the centre, or *vice versa*, the mass growing by successive additions to the lower extremity. The experiment is at once both pleasing and instructive.

ELIHU THOMPSON.

Magnetic Storms and Solar Outbursts.—Prof. Airy, in a recent communication to *Nature*, presents another fact which points to a probable relationship of cause and effect between solar disturbances and magnetic storms. Prof. Airy, in his communication, refers to an unusually violent outburst upon the sun's limit, lasting nearly four hours, which was observed by him on the 7th of July last. Upon the same day a magnetic storm occurred, which was sufficiently well marked as to cause a perceptible disturbance of the magnetic apparatus. The storm lasted for two days, and was brought to a close on the second evening by the appearance of an aurora. Taking the view that a connection existed between these phenomena, and that the terrestrial storm was the earth's response to a grand solar disturbance, Prof. Airy remarks that the time required for the latter to make itself felt upon the earth, was two hours and twenty minutes, and supposing that Pater Secchi, whose observations of the occurrence are referred to, was fortunate enough to witness the outburst from its commencement.

The Westinghouse Air Brake.—This invention, which has proven so eminently satisfactory in this country, appears to be meeting in England with equal approval. One of the leading engineering periodicals of that country in speaking of it makes use of the following language:

"The Westinghouse air brake has been fitted upon a complete train of the Metropolitan District Railway, and is working with the admirable efficiency which characterizes the apparatus. Upon this line, and indeed upon all of our metropolitan railways, where stations are placed so closely together, where the stoppages are so brief and so frequent, and where so enormous a passenger traffic exists, the adoption of an efficient continuous brake becomes, if possible, of more importance than on ordinary lines of railroads, for it is essential that the trains should be under a complete control, and that they should be brought to rest without the shock, which is the common attendant upon all ordinary and on nearly all special brakes." Engineering, Feb., 1873.

The value of the Westinghouse brake, in every needful particular, is fully proved by the experimental train now running regularly upon the District Railway, and the comparison it affords, both in regard to quickness and ease of action, with every other brake which has been tried upon the line, is most favorable.

To repeat the results of the experimental trips recently made with the train would be simply to repeat the results of experiences gained on other lines and already recorded by us. It is sufficient to say, that at each station the train of eight carriages was brought to a state of rest in half its own length, by only a partial application of the brake, the ordinary working speed never requiring the full power to be exerted.

In another paragraph the correctness of the principle which Mr. Westinghouse has adopted is thus recognized: "To bring a train from a state of rapid motion to one of rest, in the shortest possible time, is not the only duty of an efficient brake. This work may be performed, doubtless, by non-continuous brakes satisfactorily, so far as time is concerned; but there are other considerations—the passengers, the permanent way and the rolling stock—and it is only by dividing the work to be done, over as many wheels as possible, and by applying the pressure instantaneously and equally upon each, that a maximum amount of work is produced with the least possible wear upon rails or vehicles."

Iron in Missouri.—Some interesting statistical information is contained in a report upon the iron deposits of Missouri, recently published by Prof. Waterhouse. The report refers especially to the more remarkable iron localities, namely, Shepherd Mountain, Pilot Knob and the Iron Mountain.

Shepherd Mountain is about 600 feet high. Pilot Knob rises to an altitude of 1,114 feet above the Mississippi River. Its base, 381 feet from the summit, embraces 300 acres. The upper section of 141 feet is estimated to contain 14,000,000 tons of ore. Iron Mountain rises to a height of 228 feet, the area of its base being 500 acres. The solid contents of the cone have been computed to amount to 230,000,000 tons. It is thought that every foot below the surface will yield 3,000,000 tons of ore.

Artesian borings have been made and a depth of 150 feet below the surface at the base has been reached. The augur was still in ore, thus revealing a great persistence in depth, which perhaps is immeasurable. Prof. Waterhouse expresses the opinion that these moun

tains contain ore enough above the surface to supply 1,000,000 tons per annum for 200 years.

Another Steel Process.—A communication upon a method of making steel has lately been made to the French Academy, by MM. Bajoult and Roche. It is based upon the plan of partially decarburizing cast-iron by contact with a rich oxide of iron. The plan is not a new one in principle, and has frequently been the subject of trial, but the damaging influence exerted by the material upon the crucible has hitherto been a great drawback to the success of any such process. This objection the inventors above named claim to have removed.

The cast-iron and powdered ore are placed in metallic moulds, and are brought to a red heat in special furnaces. The re-action follows, and fusion only takes place after their transformation. Ingots are thus obtained, which are melted in the crucible, or on the hearth of the reverberatory furnace.

Ozonized Water.—A firm is at present engaged, in Berlin, in manufacturing ozonized water for medicinal purposes. From the prevailing opinion, which is not altogether without scientific probability, that the sanitary effects of sea air are to be ascribed to its relatively great proportion of ozone, the enterprise of the manufacturers will most likely be rewarded by a considerable demand for the substitute they claim to offer.

Cold as a Food Preserver.—M. Boussingault recently mentioned the fact that a number of samples of soup, meats, &c., which had been kept since 1865 in closed vessels at a temperature of 20°, retained all of their original qualities. The author also mentioned that the same fact was true of the juice of the sugar cane kept in a similar manner.

Slate Roofing.—An item has been extensively circulated concerning the advantage of bedding roofing slate in hydraulic cement, over the usual method of nailing them on dry, which leaves them subject to be rattled by the wind, and to be readily broken by accidental pressure. The cement soon sets, and the roof becomes like a solid wall. The additional cost of the plan is 10—15 per cent., but this, in virtue of the increased permanency claimed for the new plan, may really place a saving to its credit, in addition to which the greater security it affords against fire is a point in its favor.

Civil and Mechanical Engineering.

HYDRAULICS OF RIVERS.

By Bvt. Brig. Gen. Henry L. Abbot, Major Corps of Engineers.

Several months before the appearance of the recent series of articles upon the "Flow of Water in Rivers and Canals," contributed to the journal by Mr. D. F. Henry, it became my official duty to criticise three annual reports submitted by that gentleman to the officer in charge of the Survey of the North-western Lakes—whose assistant he then was—upon certain gaugings of the connecting rivers, made in the years 1867, 1868 and 1869. Those three annual reports furnished the groundwork for the articles in the journal, which contain some views not generally admitted by hydraulic engineers.

My reviews being easily accessible (*vide* appendices B B and B B 1, Report of Chief of Engineers, accompanying the annual report of the Secretary of War for the fiscal year ending June 30, 1870), and neither leisure or inclination favoring controversial writing on my part, the subject would not have been farther discussed, had it not been that Mr. Henry, in his recent articles, has fallen into serious misapprehensions, which call for correction, when referring to the "Report upon the Physics and Hydraulics of the Mississippi River," prepared by General Humphreys and myself. To correct those errors intelligibly, it will be necessary to state the problem presented to General Humphreys, when, in 1850, he undertook the investigation.

The low lands bordering upon the Mississippi are below the level of its floods, from near the mouth of the Ohio to the Gulf. The surplus waters accordingly poured over the natural banks, and swept through the swamps until they encountered upland ridges, which turned them back only to again leave the channel, and thus to pursue their course to the Gulf. The whole country, in its natural state, in times of flood, was thus a vast shallow lake, many miles in width. But this lake, when the floods had passed, and the waters had drained back to the channel, became a belt of alluvial land, of untold fertility and value. To reclaim it, was to win an empire from Nature. The work was begun in 1717, near the mouth of the river, by extending levees up stream. In 1850, the embankments, although quite inade-

quate, reached the vicinity of the mouth of the Arkansas, but above that point the river held undisputed possession. At that date Congress donated the swamp lands within their borders to the several river States, to provide a fund for reclaiming them, and the work was vigorously begun. But what would be the effect of this sudden and great change in the regimen of the upper river, upon the height of the floods in the cultivated region below? and, indeed, how could the upper region itself be most economically protected? This was the problem confided to General Humphreys, and upon which ten years of systematic and exhausting labor was bestowed. No small part of the difficulty was due to the fact that the science of river hydraulics was in its infancy, as the numerous citations from standard writers contained in chapter iii of the report sufficiently proves.

One cause of many of Mr. Henry's misapprehensions of the report is that he has failed to appreciate the internal evidence of the truth of its isolated conclusions, derived from the multiplicity of its checks and counterchecks. For instance: one of the problems was, to decide how much given additions to the discharge throughout the valley (known, but varying at different localities) would locally raise the water level—a problem never before attacked in a manner claiming to be even approximately scientific. To solve it, was virtually to construct a tower, each stone of which should be an hydraulic fact, established by direct observation and measurement. This was successfully done, as has been shown by subsequent observations, both by ourselves and by others; as, for instance, by the present Chief Engineer of Louisiana, Gen. M. Jeff. Thompson, who, in his report, dated December 15, 1871, says: "The facts granted in the work of Generals Humphreys and Abbot, on page 418, that an outlet of 100,000 cubic feet per second, at or near Providence, would reduce the flood level some five feet down to near Red River, has been most closely confirmed." The stability of a building carries evidence of the security of its foundations, and yet Mr. Henry attacks certain fundamental propositions, as if the evidence of their truth rested wholly on the original direct observations, and had not been abundantly verified by the correctness, experimentally proven, of numberless conclusions, both general and particular, based upon them.

But to consider his criticisms a little more in detail, and in the order in which he makes them.

He asserts that the double float which we used "had been previously tried by Mr. Charles Ellet, jr., on the same river." A little examination of the reports would have shown that the Survey had

been systematically using this float more than two months before Mr. Ellet's first trial.

He proceeds to state that "it would seem to be impossible" to read and record the angles and time while a fast float was passing through 200 feet. It would be prudent before venturing such an assertion to inspect the diagrams of our work, now deposited in the archives of the Engineer Department at Washington, and open to the inspection of any engineer. They exhibit the paths of thousands of floats, two points of each of which were fixed by triangulation, and establish by the parallelism of these paths and the accordance of the times of transit, the accuracy of the method. Long habituated to the details of exact trigonometrical surveying, Mr. Henry under-estimates the practical precision that can be secured by less elaborate field-work, and forgets that, in operating upon a moving mass of water, we may advantageously imitate the sportsman, who, in analogous circumstances, sacrifices the precision of the rifle for the superior celerity of the shot-gun.

The next point for consideration relates to Mr. Henry's own work. He gives, on page 323, a table of comparisons between the result obtained by floats and a meter at different depths below the surface, and deduces a normal difference between their indications. He states that the observations were made in the St. Clair river, "where it was over 50 feet deep;" but, by reference to the detailed tables of his official report, it will be seen that the depth, although not always mentioned, is there shown to vary between 29 and 49 feet, and that, in grouping the floats, he has considered only the depth below the surface, quite ignoring this important variation in depth of water. Moreover, although the data are the same, the column indicating "corrected difference" appears more unfavorable for the floats in his recent article than in his official report. But this question of the relative value of float and meter observations having been discussed at length in my official review, will not be considered here.

Mr. Henry proceeds to write: "In the Mississippi, the new theories of flowing water place the maximum velocity three-tenths of the depth below the surface. As these observations are the only ones which do not conform to the general law, it will be well to examine them."

This language contains several errors. Theory had nothing to do with the location of the fillet endued with the maximum velocity. Our observations established that, in any vertical plane parallel to the current, its locus varied greatly with the wind; but that, in calm

weather, it was usually below the surface. Upon these and other observed facts the new theory was based, but no part of this theory assigns any definite depth for this locus. Upon the Mississippi in still weather it is usually at three-tenths of the depth below the surface; on some other streams we found it to be higher. No general law was announced, nor is such a law of any great practical importance, because in the general formulæ for discharge the quantity disappears by cancellation. As to our observations being the "only ones" which do not conform to the Darcy-Bazin results in little canals, Mr. Henry is greatly in error. The examples he cites (all of which are quoted in the Mississippi Report) do not comprise the "only ones" ever made, nor, indeed, do they all conform to the so-called "general law." Observations upon the Po, the Chiese, the Arno, the Rhine, the Waal, the upper Mississippi, and other streams, unite with ours taken upon the Mississippi and its bayous, to disprove the general character of this "law."

Mr. Henry next devotes a couple of pages (p. 384—6) to attempting to throw discredit upon the conclusions we derived from our field data. The simple facts, which refute all his inferences, were these: Two objects were in view—to gauge the daily discharge, and to determine the law governing the action of cohesion among the fluid particles. The former required daily measurements extended quite across the river; the latter, exact and greatly multiplied observations in single vertical planes parallel to the current. In each case, the path of every float was accurately located by careful triangulation where it crossed each line, and nothing was "assumed." The intended use was made of every float observed, exactly as stated in the Report, and no other use could properly be made of it, although the observations were all entirely "reliable" for solving the problem for which they were designed.

Mr. Henry's attempted tabular exhibit of our results (p. 386) is fundamentally erroneous. No such simple analysis is possible; for the reason that all individual curves of observation contain anomalies, which must be eliminated by the cancellation resulting from the multiplication of data, before they can be discussed in detail. Until a curve is thus obtained which conforms closely to the law of continuity, only a general discussion is admissible. It is therefore hardly ever practicable to fix upon the exact locus of the true maximum velocity in a curve based upon a few observations; and this can never be done by Mr. Henry's method, of taking for the maximum the greatest velocity actually observed, without regarding the relative velocities

of other floats in the vicinity. But, even if this method of discussion were not entirely inadmissible, his proposal to reject about three-eighths of the whole data, for no better reason than that it "must certainly be erroneous," hardly accords with usual scientific rules.

As to the statement, twice repeated, that "one of the verticals in the first series gives the maximum at the bottom, or rather one foot below the bottom, as recorded," it need only be said that no observations were made at the bottom or below it, neither were any so reported. The true meaning of the record referred to is so evident upon inspection of the original text that it is quite needless to explain it here.

The next subject inviting attention is the form of sub-surface velocity curves as discussed by Mr. Henry. He gives (page 30—1, vol. lxiii) several mean curves deduced from his Lake Survey observations. Before accepting these data, reference should be made to the detailed tables contained in his official reports, whence they are derived. An inspection of these tables reveals a mathematical solecism which deprives the published means of all claims to exactness, viz., that interpolation is wholly ignored. To defend this singular method, Mr. Henry makes use of the following language: "If there are but few observations missing in a large number taken, then it will make but little difference whether we interpolate or not, for it will make but a slight variation in the mean; but if the missing observations are numerous, then (as they must be interpolated either in a straight line drawn between the known points, or in a curve) the mean will approximate more or less to the line or curve by which the interpolations were made."

The fallacy of this reasoning is best illustrated by an example taken from one of his own detailed tables, giving the subsurface velocities in the Niagara river, as observed in 1868.

Observed Velocity of River at the following Depths.

Date.	20	25	30	35
July 22d,	2·730			2·789
27th,	4·680	4·412	4·119	3·969
29th,	4·551	4·220	3·857	3·676
Means as published,	3·987	4.316	3·983	3·478
True means,	3·987	3·794	3·582	3·478
Mr. Henry's error,		0·522	0·401	

A simple diagram will make the error of such a method of grouping observations apparent to the eye, and will show that before any well-grounded opinion as to the form of curve indicated by Mr. Henry's observations can be formed, an entire recomputation of his published means is necessary.

He proceeds to test by two of these supposed mean curves, the various forms proposed by hydraulic engineers—among others the "parabola of Humphreys and Abbot," which he concludes to be the "worst form" of all. This adverse opinion is due to his assuming an unwarranted value for the depth of axis, as may easily be shown. Since his own figures indicate that our parabola, when applied to his supposed mean curve for the St. Lawrence, has a maximum discrepancy of only 0·058 ft., and a mean discrepancy of only 0·022 ft. per second, it would be a waste of time to see if the accordance is not really more close. For the St. Clair river, however, his error of applying the formula is more serious, and calls for correction. In so doing, the surface velocity is neglected, since he frankly admits that it is "not properly taken."

St. Clair River—Depth from 44 *to* 47 *feet.*

Depth of Obs.	Observed velocities per second.	Humphreys and Abbot parabola as computed by Mr. Henry.		Humphreys and Abbot parabola correctly computed.	
		Curve.	Difference.	Curve.	Difference.
	3·868	3·564	—0·304	3·990	
5	3·907	3·573	—0·334	3·907	+0·000
10	3·821	3·564	—0·257	3·804	+0·017
15	3·709	3·536	—0·173	3·683	+0·026
20	3·608	3·489	—0·129	3·543	+0·065
25	3·496	3·423	—0·073	3·384	+0·112
30	3·309	3·339	+0·030	3·206	+0·103
35	3·100	3·237	+0·137	3·010	+0·090
40	2·678	3·115	+0·437	2·794	—0·116
42·4	2·388	3·050	+0·662	2·684	—0·296
45·4	1·428	2·962			
Sums,	33·884		2·536		0·825

One important fact is not to be forgotten in any comparison of these several proposed forms of curve. Other engineers simply give

a general form, leaving such valves of the constants to be selected, in each individual case, as shall cause the best possible accordance between the theoretical and observed velocities. In our parabola, a general equation for the parameter, depending upon the mean velocity and depth, is given; and the form of the curve is, thererefore, definitely fixed. Bearing this in mind, it is considered that the comparison instituted by Mr. Henry, freed from his errors of misapprehension, shows our curve to be fully equal to any of the rest, even as tested by these uncertain means.

Mr. Henry concludes by regretting that we did not select an ellipse, instead of a parabola, as most nearly indicating the law of variation. This was not done, because our ample data did not so indicate the law. But even if it had been found that an ellipse would give a slightly closer accordance with observations than a parabola, that curve would not have been selected, because we had to make a practical use of it in framing new formulæ for the discussion of higher branches of the subject of river physics; and the areas bounded by parts of an ellipse form a complicated series, while those bounded by parts of a parabola may be expressed in terms of a simple rectangle. This advantage would have been decisive, even if we had found (which we did not) that an ellipse would accord more closely with observation than a parabola, by a few thousandths of a foot of velocity per second.

But the truth of the Humphreys-Abbot theory for this curve does not, at this date, rest simply upon the Mississippi observations. The matter has been carefully studied since—among others by von Heinr. Grebenau, who has submitted thirteen old sets of observations, made by Zendrini, Lecchi, Lorgna, Zimenes, and Brüning, and not accessible to us, to careful analysis, with the following conclusion: "It is remarkable that the law of decrease" (our parabolic law), "which is obvious in all of these earlier experiments, could have remained so long unknown." He also made some careful measurements himself on the Queichbach, near Germersheim, which not only confirmed our parabolic law, but also verified our general equation for the parameter of the curve. Other observations of similar character might be named.

In his remarks upon the mean velocity of rivers, among other errors relating to the Mississippi Report, Mr. Henry has given a partial extract from a paper written by me for the Essayons Club of the Corps of Engineers, which wrongly conveys the impression that the

new data published in the work of Darcy and Bazin did not confirm our formula. In reality, I showed that they verified it in the most complete manner, and even afforded authority for extending its use to a class of small natural streams, with great slopes, to which it was not claimed to be applicable in the Mississippi Report. The valuable work of MM. Darcy and Bazin extended the table of trustworthy observations upon natural channels to a total number of seventy-three, only four-tenths of which were to be had in framing our formula; yet its average percentage of error is only six per cent,, or about that of careful actual measurement. Our formula was based upon every observation we could procure, of an exact character, published either in this country or in Europe; and no "selection," except upon grounds which were fully explained, was made. That good judgment in this respect was used is sufficiently shown by these new Darcy-Bazin data.

Mr. Henry also gratuitously infers a "disagreement" in our Mississippi levels, which had no existence in fact.

In giving the results of his own slope measurement on the St. Clair river, and applying the several formulæ to them, he does not state —what his official reports show to be the fact—that the discharge was measured at widely different dates from the slopes, and hence, probably, bore no relation to them.

In proposing to substitute six-tenths of the depth for the mid-depth recommended by us as the uniform locus of velocity measurements for discharge, Mr. Henry has failed to appreciate that he would thus introduce a variable error due to wind effect. His own figures and computation show that our simple mid-depth method, when compared with his own laborious and costly operations, exacting observations at all depths, gave results differing only by seven-tenths of one per cent. in the discharge of the St. Clair, by two and seven-tenths per cent. in that of the Niagara, and by one-tenth of one per cent. in that of the St..Lawrence.

In now finally closing this dicussion, so far as I am concerned, I would cheerfully accord much credit to Mr. Henry for his ingenuity in the application of electricity to recording the revolutions of a submerged meter axle. In this he has made a real contribution to the accuracy of hydraulic measurements in wide harbors and tidal ways, where operations from the shore are hardly practicable.

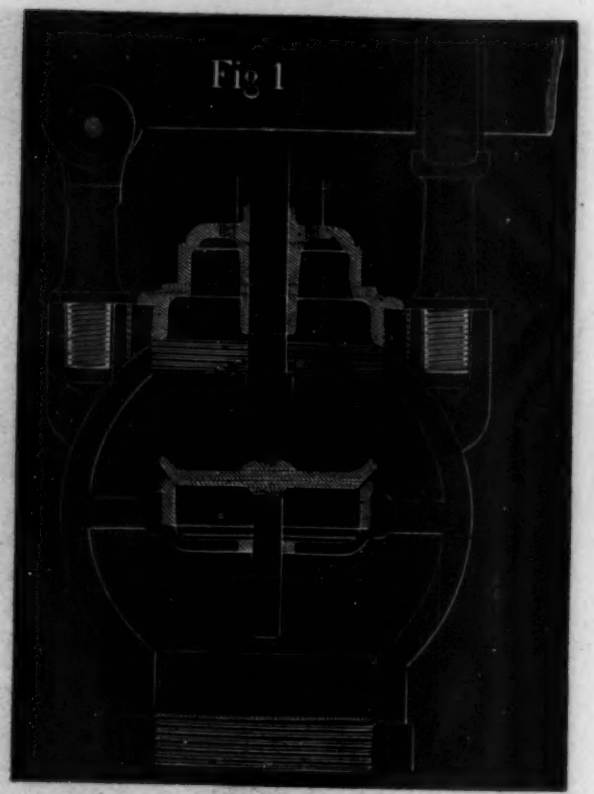


Fig 1

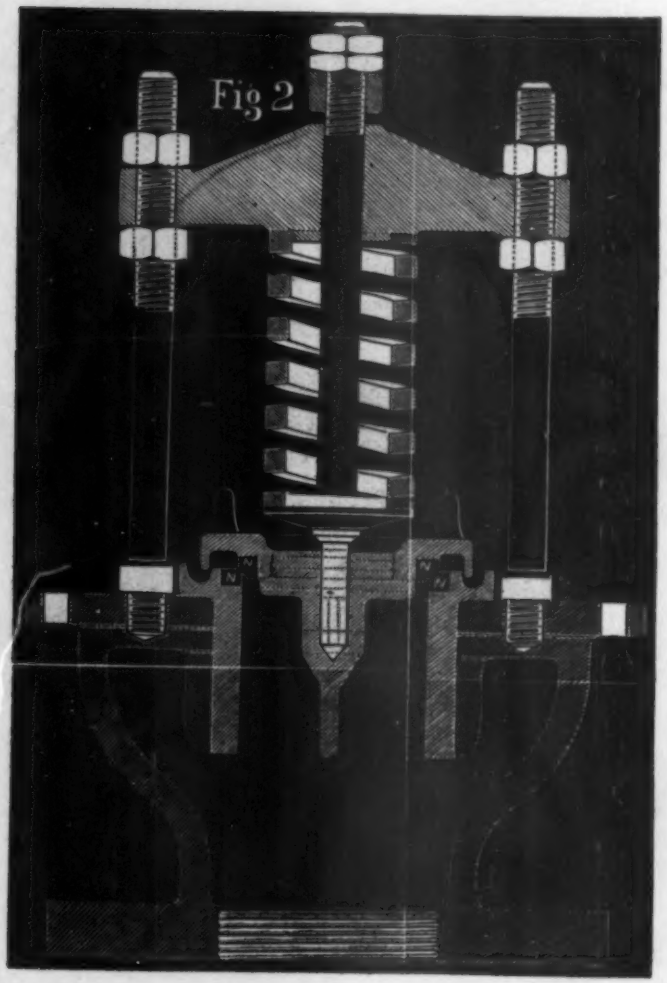


Fig 2

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THE NICKEL SEATED SAFETY VALVE.

{ CHIEF ENGINEER'S OFFICE,
{ WASHINGTON, *December 2d*, 1872.

Rear Admiral L. M. Goldsborough, U. S. N., Commandant.

SIR:—In obedience to your order of September 12th, 1872, to test the "Nickel Seated Safety Valve," manufactured by E. H. Ashcroft, of Boston, Mass., and report upon its advantages and disadvantages, I beg leave to submit the following:

The boiler used for the test was of the cylindrical horizontal tubular type, six feet in diameter, twenty feet long, grate surface twenty-two square feet, heating surface nine hundred and twenty-eight square feet, and of about thirty nominal horse-power. Pressure of steam used in the test from sixty-five to eighty pounds per square inch.

The experiments were comparative, and were made with seven valves, of the common kind, of the following diameters, viz.: 4″, 3″, $2\frac{9}{16}$″, 2″, $1\frac{23}{32}$″, $1\frac{13}{32}$″, and 1″, and seven of the nickel seated valves, of diameters 4″, 3″, $2\frac{1}{2}$″, 2″, $1\frac{1}{2}$″, $1\frac{1}{4}$″ and 1″. The object was to ascertain the lift and area of opening given for the escape of steam when the valve was acting freely and blowing off at full pressure of steam, and to ascertain how much the pressure could be increased after the valve was in full operation. The lift was ascertained by securing scratchers against the valve stems. The results can be seen by referring to the accompanying diagrams. The outer circles represent the circumferences of the valves. The areas of the inner circles represent an area equal to that given for the escape of steam by the circumference and full lift of the valve when blowing off at the limit of pressure.

In these respects the nickel seated valve possesses an advantage which places it beyond comparison. The 4″ common valve, when blowing off at the limit of pressure, had a lift of $\frac{1}{20}$ of an inch, giving an area for the escape of steam of $\frac{63}{100}$ of a square inch. The nickel seated valve of the same diameter, operating with the same pressure, had a lift of $\frac{1}{4}$ of an inch, giving an area for the escape of steam of 3·14 square inches. The 3″ common valve had a lift of $\frac{1}{17}$ of an inch, giving an area of opening of $\frac{56}{100}$ of a square inch, while the 3″ nickel seated valve had a lift of $\frac{3}{16}$ of an inch, giving an area of opening of 1·76 square inches. In the experiment to ascertain how much the pressure could be increased while the valve was blowing off at the limit of pressure, with the 4″ common valve, which is about the diameter used on boilers of the size mentioned, the pressure was

increased five pounds in four minutes, without any apparent increase in the lift, and the experiment was stopped. With the 3″ valve the pressure was increased nine pounds in six minutes. The 4″ nickel seated valve operating under the same circumstances opened to its full lift as soon as the limit of pressure was reached, and the pressure could not be increased, but it steadily decreased to a point a little below the original pressure, when the valve suddenly closed. With the 3″ valve the pressure was held at the limit of pressure. In both cases the fires were in active condition and the furnace doors closed.

This experiment proved that the lift of the common valve is not sufficient, and will not increase with the pressure, by its own action, sufficiently to relieve the boiler under all circumstances, and that the pressure can be increased until an explosion takes place, while the valve is in operation, and therefore it is not, in reality, a safety valve.

The nickel seated valve, under the same conditions, obtained its full lift instantaneously by its own action, giving an opening of sufficient area to relieve the boiler at once.

The common safety valve needs no description. The nickel seated valve is automatic, and can be used either as a lock-up or an open valve. It is actuated in its resistance to the steam pressure by a spiral spring of the most accurate workmanship, and plated with nickel. The face of the valve coming in contact with the seat is composed of a solid ring of nickel. The valve seat is also of solid nickel. The qualities of this metal form one of the most important features in this valve. Its great hardness insures its resistance to wear. It is not affected by the action of steam and the saline matter in water, and, being non-corrosive, it is free from the possibility of sticking, as is often found to be the case with the common valve, by corrosion, and which may be attended with the most fearful consequences. The valve is constructed with a curved lip, as seen in the accompanying drawing, so that the main body of the steam, as it escapes from the boiler, being directed downward, strikes against the bottom of a suitable recess surrounding the valve seat, and the recoil of the steam acting upwards against the under surface of the valve as it issues into the atmosphere assists the valve in obtaining a higher lift. This action is sure and instantaneous, and it was found that the greater the steam pressure the higher the lift, using the same spring. For instance, with a 3″ valve, the spring being set to open at sixty pounds, the valve will lift full $\frac{1}{8}$ of an inch, and with the same spring set to open at eighty pounds, the lift will be $\frac{3}{16}$ of an inch. The lift of the common valve will remain the same at any pressure, the weight

on the lever being adjusted to the given pressure as in the case of the spring. For instance, if the weight is adjusted to yield to a pressure of twenty-five pounds, the lift of the valve will be about $\frac{1}{32}$ of an inch, and if adjusted to a pressure of eighty pounds, and raised by the steam, the lift will be the same.

The late experiments at Sandy Hook, N. J., on steam boiler explosions, have disposed of many old theories regarding this subject, such as electricity, formation of gases, the sudden generation of steam of an enormous pressure, &c., &c., and have proved that explosions of the most destructive character can occur by the gradual accumulation of steam and with the moderate pressure of fifty three and one half pounds per square inch.

It was also observed that it required but thirteen minutes to raise the pressure from thirty pounds, the working pressure allowed for this boiler, to fifty-three and one-half pounds, when it was torn into fragments, and a part of it, weighing three tons, was hurled four hundred and fifty feet from its original position, showing that the neglect of only a few minutes, together with an inoperative or inefficient safety valve, are all that are required to produce the most frightful results.

The subject of safety valves, heretofore so much neglected, is receiving considerable attention in England and elsewhere, and the experiments made with the common valve corroborate some of the above statements. Under whatever circumstances explosions may occur, the real cause is excessive pressure, and the fact that such disasters do occur, whether from neglect or otherwise, involving fearful loss of life and property, points forcibly to the necessity of providing against them in every possible way, and the only safeguard that can be applied to a steam boiler is a safety valve, that is automatic, certain in its action, prompt in opening and closing at the required moment, and that can be fully relied upon to relieve the boiler under all circumstances.

It is impossible to provide against the contingent dangers of a steam boiler, such as the hidden imperfections of the iron, the chemical action to which they are subjected, &c., but for the prevention of any pressure in excess of that allowed, I am fully of the opinion that the "Nickel Seated Valve" is the only one that fulfills the requirements.

Very respectfully your obedient servant,

EDWIN FITHIAN,

Chief Engineer, U. S. N.

REPORT ON BOILER INCRUSTATION.

HANNIBAL, Mo., *May*, 1872.

To the American Railway Master Mechanics' Association:

GENTLEMEN,—The Committee to whom it was your pleasure to again refer the subject of Boiler Incrustations, their Causes and Cure, would respectfully report that they have given the matter as serious a consideration as the time and its great difficulties would permit.

In accordance with former practice, circulars of inquiry have been addressed for information to various parties, but to such only as might have something to offer, from investigations made since our last annual meeting. We regret that no new or important information has been elicited, throwing additional light upon the subject; your Committee being therefore unable to present any new facts, will have to confine itself to an allusion to the experiments which have been going on for the past two years, and also to speculation upon the relative cost of purifying water before it is taken into the boiler, if, indeed, such a thing can be accomplished at all. In justice to Mr. J. H. Setchel, who has written at considerable length on the subject, the Committee would suggest that his communication be read in full.

The use of pure water is universally recommended as being the only effectual remedy. Some, however, are still experimenting with fluids, powders, batteries, etc. It will be remembered that the plan, or a similar one, recommended last year by Mr. S. J. Hayes, of the Illinois Central Railroad, was indorsed by the Committee, and embodied in their report as the fundamental principle through which this great evil can only be effectually overcome. It is the opinion of your Committee that the impurities contained in water will precipitate sufficiently for practical purposes after a certain amount of boiling, but whether this method of purifying can be made practicable and cheap is a question which we cannot from our own experience determine. We are not prepared to believe that chemical means alone can be economically employed for the precipitation of the materials in water which form incrustations; but to this we shall again refer. A subject which has so long baffled the skill of the leading scientific and practical minds at home and abroad, cannot be properly treated without reaching in vain after the necessary data to make the article wholly reliable and conclusive. We think so great an evil as boiler incrustations, involving in its range violent explosions, loss of life, and great destruction of property, should have the combined effort of

scientific and practical men towards the development of a remedy; and to this your Committee, fully realizing the extreme difficulties of the subject, have invited the co-operation of eminent chemists and scientists, and from them they have not as yet obtained anything sufficiently definite to warrant its presentation, and hence they feel that the only way left open to them by which they can discharge their duty to themselves and the Association, who have honored them by their appointment for this particular office, is to present their own crude and imperfect ideas and experience for what they may be worth. It was thought that enough was said upon this subject last year to stimulate an interest on the part of railway companies in the manner of purifying water before using it in their engines, but we have failed to hear of any experiments in that direction.

Your Committee do not believe a remedy can be devised without more or less experimenting, all of which must necessarily be attended with considerable expense; but they will endeavor to show that at least some economy may be the result.

The plan which we shall attempt to explain is one which we believe will nearly if not quite purify the water before it is taken into the boiler, and it is yet hoped, by the introduction of chemical agents, that this method may be simplified and prove practicable and cheap. Not having tried any experiments in this direction ourselves, we shall be confined to the experience of others to prove our theory, and will first refer to a paper prepared as a report of experiments made by Professor C. F. Chandler, of Columbia College, New York, to the President and Directors of the New York Central Railroad Company upon the various kinds of water used by the locomotives of that Company along the line of that road, with an analysis of the waters, showing their composition, and also an analysis of the scale formation from such waters, and what chemical agents and processes would decompose and prevent the same. The report was read before the American Institute Polytechnic Association, January 11, 1866.

The following article appears in this report: "Boiling expels the free carbonic acid and causes the separation of the carbonates of lime and magnesia, and if conducted at a high temperature, under considerable pressure, results in the almost complete precipitation of the sulphate of lime. This would, however, merely transfer the incrustations from the locomotive boiler to some other vessel and would, therefore, be valueless in this case." This is just what we desire to do, transfer the incrustation from the locomotive boiler to some other

vessel provided to receive it and so arranged that the sediment may be removed at pleasure. Then supervenes a difficulty in the use of chemicals for precipitating the lime, etc., from the water, which seems to offer two insuperable objections. The first found is in the nature of the chemicals used; for, whilst precipitating the matter forming incrustations, they may corrode the metal itself. All chemicals would have to be used to purify the water before entering the boiler, in order to avoid this corrosion and also the precipitation into it, which would still demand cleansing of the foreign matter. Then a second objection arises out of the wide differences of water in the different sections; whilst incrustations are formed from those which contain lime, yet there may be and is such a difference of chemical admixtures as to render it wholly impossible to find any one universal chemical sufficient to dissolve these different elements. Hence we feel the necessity of looking somewhere else than to chemical solvents alone for a solution of the difficulty.

If Professor Chandler's theory be correct, an apparatus can be easily arranged at each water tank along the line of the road by which the water may be heated, and if desired subjected to a pressure, before being taken into the locomotive boilers. From his statement we may assume that the impurities in water will precipitate at a temperature of two hundred and twelve degrees; if this be true, the best and cheapest method of heating the water to this temperature, and its treatment after being so heated, only remains to be proven, and your Committee would suggest the following plan: Let each watering station on the line of the road be provided with a pumping engine or steam pump, with a capacity in proportion to the amount of water required. The exhaust steam from the pump should be conducted into a suitable heater, together with as much live steam as may be necessary to raise the water to a boiling heat. The heater being closed, the water within it at the boiling point would be subjected to a pressure of about fifteen pounds to the square inch. The heater should be made of iron, and as large, perhaps, as one-third the capacity of the tub. While the heater is being filled the water should be raised to the boiling point, after which the calcareous and other matter in suspension should be allowed time to settle, when the water can be drawn off into the tub arranged to receive it. After the heater is emptied the sediment may be blown off, and this process repeated until the tub is filled, thus keeping up the supply of purified water according to the demand.

The expense attending this apparatus would be equal to the cost of a No. 4 Knowles steam boiler and pumps complete—$450—together with the heater and its fixtures all told would not exceed $1000; and deducting from this amount the value of the present machinery employed, consisting of one ordinary horse-power and a four-inch hand or power pump, would make actual expense of first cost at such watering station about $800. The second cost, or continual expense, may be estimated in proportion to the amount of fuel consumed for the purpose of heating the water. Assuming as a basis that one pound of coal will evaporate eight pounds, or one gallon of water, we would only have to estimate the amount of coal consumed to arrive at the approximate consumption of water. It has been proven by experiment that if five and a half pounds of water, at a temperature of thirty-two degrees, be placed in a vessel communicating with another one in which water is kept constantly boiling at the temperature of two hundred and twelve degrees, until the former reaches the temperature of the latter quantity and is then weighed, it will be found to weigh six and one-half pounds, showing that one pound of water has been received in the form of steam, through the communication, and reconverted into water by the lower temperature in the other vessel. Now this pound of water received in the form of steam had, when in that form, a temperature of 212°. It is now converted into the liquid, and still retains the same temperature of 212°, but it has raised five and one-half pounds of water from this temperature of 32° to 212°, and this without losing any temperature of itself. It follows, then, that in returning to the liquid state it has parted with five and one-half times the number of degrees of temperature between 32° and 212°, which is equal to 180° and $180° \times 5\frac{1}{2}° = 990°$. Now this heat was combined with the steam, but as it is not sensible to a thermometer it is called latent heat. It is shown, then, that a pound of steam in passing from a liquid at 212° to steam at 212° receives as much heat as would be sufficient to raise it through 990 thermometric degrees, if that heat, instead of becoming latent heat, had been sensible, and $990° + 212° = 1202°$, being the whole amount of heat in steam. Hence it will be seen that one pound of coal, capable of evaporating eight pounds of water, will raise to the boiling point about five and one-half times as much, say forty-four pounds, or five and one-half gallons of water. To this must be added the relative value of the exhaust steam from the pumping engine, which will be equal to five and one-half times the amount of water evaporated in pounds.

Supposing, for example, that one locomotive running 2600 miles a month, or 31,200 miles a year, will make 45 miles to one ton of coal; it would then consume 693 tons of coal per year, at $2.50=$1732.50. If this locomotive will evaporate six pounds of water to one pound of coal, it will require 8,316,000 pounds, or 1,039,500 gallons of water. It is estimated that a No. 4 Knowles steam pump will raise 5940 gallons of water an hour. In doing this work it will consume about 60 pounds of coal, requiring 10,500 pounds to pump the whole amount of water. If the pumping engine will evaporate eight pounds of water to one pound of coal, the exhaust steam will boil about five and one-half times this amount, or forty-four pounds of water to one pound of coal, equal to $10,500 \times 44 = 462,000 \div 8 = 57,750$ gallons. This would leave 981,750 gallons to be boiled by the use of live steam from the boiler, which will require one pound of coal to five and one-half gallons of water, or $981,750 \div 5\frac{1}{2} = 178,500$ pounds coal $\div 2000$ $89\ \frac{250}{1000}$ tons. This, added to the amount of coal required to pump the water, would make about $94\ \frac{500}{1000}$ tons, at $2.50=$236.25, total expense for fuel in purifying the water in one engine for one year. Boiler repairs, including machinists' labor in taking down and setting up machinery that would not be otherwise done, would amount to about $550 a year. Of this amount fully sixty-five per cent. may be due to incrustations alone. Judging from reports received by your Committee from Eastern and Southern roads using water, from which no incrustations form, where boilers run from fifteen to twenty-seven years without repairs, it may be safe to assume that even seventy-five per cent. will be saved by the use of pure water. But granting that only sixty-five per cent. is saved, the actual cost of boiler repairs due to incrustations would then be $357.50.

We will now consider the extra amount of fuel necessary to heat the water through the increasing formation of incrustations, which we will attempt to illustrate as clearly as possible, from the best information we have been able to gather, from both theory and practice. Dr. Joseph G. Rogers, in a paper on steam boiler waters and incrustation before the American Association for the Advancement of Science, says: "The evil effects of scale are due to the fact that it is relatively a non-conductor of heat. Its conducting power compared to that of iron is as 1 to $\frac{17}{60}$. This known, it is readily appreciated that more fuel is required to heat water through scale and iron than through iron alone. It has been demonstrated that a scale $\frac{1}{16}$ of an inch thick requires the extra expenditure of fifteen per cent. more

fuel. As the scale thickens the ratio increases. Thus, when it is one-fourth of an inch thick, sixty per cent. more is required; at one-half inch, one hundred and fifty per cent., and so on. To raise steam to a working pressure of ninety pounds the water must be heated to 320° Fahrenheit. This may be done through a one-fourth inch iron shell by heating the external surface to about 325°. If a one-half inch scale intervenes, the boiler must be heated to 700°, almost a low red heat. The higher the temperature at which iron is kept the more rapidly it oxidizes, and at any temperature above 600° it soon becomes granular and brittle from carbonization or conversion into the state of cast iron. Weakness of boilers thus produced predisposes to sudden explosions and makes expensive repairs necessary."

On most of Western roads incrustations will form to a thickness of from one-eighth to three-sixteenths of an inch in the course of one year, and increases at a still greater ratio as long as the engine is kept in service. Thus, after four months' time, there will have accumulated in our engines nearly one-sixteenth of an inch of scale. This statement will be verified by a specimen presented for your inspection, consisting of a piece of two-inch flue taken from an engine on the Hannibal and St. Joseph Railroad after three months' service, to which is adhering a scale nearly one sixteenth of an inch thick. If Dr. Rogers' theory be correct, after one month's service our engines will consume three and one-fourth per cent. more fuel than at first; after two months' seven and one-half per cent., and so on, making an average for the year of over twenty per cent. more fuel than they would have consumed if using pure water. This, according to the performance of the best coal-burning engines, making forty-five miles to one ton, will amount to an extra expenditure in fuel of not less than 138½ tons at $2.50, making $346.25 due to incrustations. This, being added to the expense of repairs due to incrustations, will make $703.75. In addition to this the expense of washing boilers may be counted; as by the use of pure clear water boilers will seldom require washing, and the expense of at least $1 per week or $52 per year would be saved to every engine, swelling the total to $755.75, or $519.55 more than the cost of purifying the water by this process. From this it will be observed that to boil sufficient water to supply a locomotive for one year, running 31,200 miles, will require the extra expenditure of $236.25 for fuel. Now, if boiling alone will purify the water, there would be a saving of $519.50

to each engine, or $51,950 for one hundred engines. Besides all this the use of pure water will absolutely prevent all manner of explosions, ruptures and leaks, arising from the effects of incrustations. It will also save a large proportion of the repairs to the machiney, not counted in the above estimate, by always supplying the cylinders with pure dry steam of the best quality, free from loose sediment or grit, which always follows the course of the steam, frequently cutting the valves, pistons and cylinders, and otherwise damaging the machinery of the engine. The use of water free from mud and organic substances, will absolutely prevent the evil of foaming, which so frequently almost unfits an engine for usual services, until it can reach its destination and be washed out. This and many other prolific evils arising from the use of impure water would, beyond a doubt, be entirely overcome. The introduction into a boiler of any so-called remedies, be they powders, batteries, fluids, or any other nostrums, can hold no comparison whatever to this one perfect and only reliable remedy. Any experiments towards the providing of pure water for locomotive use is a step in the right direction, and when railway companies are aware of the fact that in the Middle and Western States the expense due to impure water and incrustation would amount to the enormous sum of about $75,000 a year for every hundred locomotives, we think they can afford to give the subject a little consideration with a view to making some practical experiments by which reliable and satisfactory results may be reached. The matter of thoroughly purifying the water at a moderate expense is so extremely difficult, that your Committee are not prepared to suggest any particular plan other than that already recommended, believing that nothing in this direction can be definitely known without more or less experimenting.

Mr. Towne, of the Hannibal and St. Joseph Railroad, has been investigating for the past two years with an apparatus consisting of an ordinary dome, 25 × 25 inches, riveted to the top of the boiler in a convenient locality to the pumps of the engine, so that the water supply can pass freely through the check pipes to the top of the dome, where it is discharged and caused to fall upon and ripple over a series of heated plates, circular in shape, provided with a series of ribs or stops on their upper surfaces to retard the momentum of the water, and arrest the sediment as it passes from one plate to another in its course to the boiler. After passing over these plates the water forces its way through a filter, thence to the boiler through a number

of one-inch pipes (as per tracing) through which also steam from the boiler is admitted to the dome, distributing itself around and within the heater, maintaining a constant equilibrium of heat between the apparatus and the boiler. Half of these plates are slightly convex and half concave, causing the water to flow from center to side and side to center alternately, passing through holes or slots in each plate on its way to the filter, and finally to the boiler through said pipes, which extend upwards about five inches, forming on top of the boiler (within the heater) a basin for water and a receptacle for any sediment that might lodge there, whence it could be blown off by means of pipes arranged for the purpose.

The filter was composed of coarse gravel, and soon found to be of no practical use beyond the lodgement of more or less incrustation. The shelves were found to gather from one-sixteenth to three-sixteenths of an inch of incrustation in from six to twelve weeks' time, showing clearly that the principle was correct, but the apparatus entirely too small to arrest all the lime, as the boiler and flues were also found to be thickly coated, especially so directly under the heater where the water had fallen upon the flues scale had formed from one-fourth to three-eighths of an inch in thickness. After running this engine about sixteen months without any satisfactory results beyond that already stated, it was taken in for temporary repairs, and the heater re-arranged with a view to getting the greatest possible amount of heating or plate surface within its capacity. The filter was accordingly taken out, and the boiler cut out to the size of the internal diameter of the dome, and an additional number of plates put in, about one and a half inches apart, filling the dome full, making sixteen plates in all—a plate surface of about fifty superficial feet. In addition to this a circular strip of sheet iron, four feet long, was placed inside the boiler, directly under the heater, its ends being flanged upward about two inches, filling the circle of the boiler, and its sides extending downwards to within a few inches of the bottom of the boiler. This was to prevent the water from the heater coming in contact with the flues, and also to provide a still greater heated plate surface, over which the water must travel before reaching the boiler, making, all told, about eighty-two superficial feet of heating surface. The engine is now running with this apparatus, and although it arrests so much lime and mud that it is found necessary to take out the plates and clean them off occasionally, yet it does not seem to stop all the incrustations, and consequently it is not just the thing. Judg-

ing from these experiments, as well as others, we do not believe that any apparatus of this kind can be got on to an engine of sufficient capacity to purify the large amount of water required for a locomotive boiler. We think the same device, or a similar one, arranged at watering stations along the line, on a larger scale, might be made to do the work effectually at less expense perhaps for fuel than the first plan. If not by that alone, the introduction of chemical assistants, at a trifling cost, might have the desired effect. The first plan, however, would seem to be the most feasible. The importance of this subject cannot be overrated, since it is known that among the many evils of incrustations none are more potent than the fact of boiler explosions from this cause, and nothing can be surer than pure water as a remedy for this class of explosions. There are cases of explosions of boilers at pressures that, without proof to the contrary, may be taken to be very much below their power to resist pressure, showing very clearly that boilers do explode from causes yet unknown. It is, then, reasonable to suppose, since the fact is not known, that impure water and incrustations may be the source of this unknown element of destruction. Should it be, however, only one cause of such terrible disasters, one point will have been gained; for a single remedy absolutely known is worth more than all the speculative theories extant, as it may lead to the development of a final cure, and in time boiler explosions, other than those caused by low water and over-pressure, will no longer be a mystery.

In conclusion, your Committee feel that they are groping in the dark, and cannot conceal from themselves what must be apparent to others that the question is yet an open one, and whether the theory advanced will effect a complete solution of the difficulty yet remains to be proven by actual trial. To this end we would respectfully invite the attention of all interested, and recommend a series (if possible) of exhaustive experiments, without which they are convinced nothing definite in this direction can ever be known.

Respectfully,

H. A. Towne, *H. & St. J. R. R.*,
J. Johann, *P. R. R., of Mo.*,
J. M. Boone, *P. F. W. & C. R. R.*,
Committee.

In connection with this report the following letter from J. H. Setchel, Little Miami Railroad, was submitted and read:

Mr. Setchel on Boiler Incrustations.

H. A. Towne, Esq., Chairman Committee on Boiler Incrustations:

Dear Sir,—Originally the water on this road was all very hard; but since the introduction of coal as a fuel the necessity of soft water has been so apparent that strenuous efforts have been made to obtain it.

At Cincinnati the water of the Ohio River is used, and but little incrustation is found in boilers using this exclusively; and even after engines have run on other divisions and have become heavily scaled, a year or two's use of this water will in a great measure remove it.

At Columbus the water of the Scioto River is used, and with about like results. Within the two points named, where the water is mostly taken from wells, it is highly impregnated with lime, forming on flues and boilers a hard, flinty scale. On one division, of fifty-seven miles, we have more trouble than on any other part of the road. Here the water is taken from wells and is very hard; and, in running this division, we can take engines upon which we are required to do more or less flue work every few weeks, and by transferring them to the main line we are enabled to run them without difficulty. I can account for this only on the score of the difference in the quality of water used.

We do not take out flues for the purpose of cleaning them, but run them as long as they can be kept tight. Copper flues, in engines burning wood, will run from 150,000 to 200,000 miles. Iron flues, in engines with coal as a fuel, will average from 50,000 to 80,000 miles. We find that the life of the bottom part of boilers seemingly varies with the quality of iron used. We sometimes find a new boiler eaten out in spots in the bottom part after running three years. This I attribute, to some extent, to the rough places often left in iron by using too much sand on the rollers while the iron is in process of manufacturing. In forming sheets into shape this sand that has been pressed in the iron often drops out and leaves a thin, rough place in the sheet, to which the scale adheres and enters on the work of destruction, and subsequently form the eaten places for which the bottom sheets are taken out. I know the destruction of the bottom part of boilers is often attributed to scale and vegetable matter held in solution in this part of the boiler; but, when you learn our method of cleaning boilers, I think you will agree with me that this can hardly

be the case here. I have tried most all the "sure remedies" for preventing and removing scale that has been in vogue for the last five or six years without any positive good result. I have used John Bull's scaling powder in boilers that were thickly coated, and have found that it will remove scale to a noticeable extent. The engines would steam better and large quantities of scale and mud would be taken from the wash-out plugs for awhile; but, in my experience, I find that at certain seasons of the year our boilers will scale more or less without any artificial means being used. Our freight engines are run one hundred and twenty miles four days in the week. This gives two lay over days, and on one of these days the water is let out of the boiler when comparatively cold, and the bottom part of fire box is thoroughly cleaned of all mud and scale. A two-inch hand hole plug is placed at each corner of fire-box that readily admits of the introduction of rods and hose nozzles for this purpose. In the front end, at bottom of flue sheet, is another hand hole plug large enough to admit of a rod with auger or hook-shaped end. Once every two weeks this plug is removed and the cylinder part of boiler is thoroughly washed together with the leg of fire-box as before. This process keeps the boiler free from mud, but does not, of course, prevent the formation of scale. To effect the latter I have tried almost everything. Of the mixtures to put inside for the purpose of removing scale I have found none better than the one before mentioned—"John Bull's." I am now experimenting with Hay's "Galvanic Battery" on three boilers; but it has not yet been in use a sufficient length of time for me to form any opinion as to its merits. I know of nothing that will effectually prevent the formation of lime in boilers. I should think that, where water is used containing sand or vegetable matter in solution, a filter might be useful in arresting such impurities. Some years ago we were a great deal troubled by the filling up of the space between the crown-bar by deposits of mud and scale, but since the practice of giving an inch clearance under the bar has been adopted, and the quality of water been improved, we have little or no trouble from this cause.

Respectfully yours, J. H. SETCHEL,

Master Mechanic Little Miami Railroad.

Chemistry, Physics, Technology, etc.

NOTES ON THE VIENNA UNIVERSAL EXPOSITION.

(From our German Correspondent.)

LEIPSIC, *November*, 1872.

The preliminary arrangements for the World's Fair to be held in Vienna during the summer of the year 1873, have progressed so far as to enable me, especially in what concerns the arrangement of the buildings, to form a correct idea of its character.

In the following description, I have confined myself generally to facts as promulgated from official quarters, adding, however, thereto such few comments as seemed to be warranted from personal observation.

In the great fairs which have heretofore been held, the object has been kept constantly in view to display the accumulated master-pieces of human genius and industry in a building which should, in its grandeur and elegance, be worthy of its contents; so that the palaces which have been erected for such purposes have made an impression upon the minds of the visitors of the expositions no less lasting than the objects of art and industry therein displayed.

Many of these palaces have been removed at the close of the exposition which they served. Others, again, have outlived their temporary purpose, and have remained standing; so, for example, has it happened with the Sydenham Crystal Palace and the Palais de l'Industrie—the first of which served its original purpose in 1851, the latter in 1855.

In arranging for the coming World's Fair, in 1873, it seems to be one of the chief objects of its Director-General, Baron von Schwarz-Senborn, to accomplish the erection of a palace which shall, in its plan, extent and surrounding decorations, be in no particular inferior to those which have preceded it.

The efforts which are being made with this object in view are notably aided by circumstances of a local nature. The city of Vienna possesses in her Prater a natural park which, no less by its extent than by its picturesque beauty, is admirably adapted for the purposes of such an exhibition.

With this excellently adapted location, it is rendered possible to appropriate to the purposes of the Vienna Fair an area which shall surpass all others previously held, not excepting that of 1867, in Paris, on the Champ de Mars.

The accompanying table, containing the areas of former exhibitions, will serve to show this feature by comparison with that appropriated for the coming event:

The space included for the purpose of the Exhibition was, at

London (Hyde Park),	1851, =	81,591	sq. metres.
Paris (Champs Elysees),	1855, =	103,165	"
London (Brompton),	1862, =	186,165	"
Paris (Champ de Mars),	1867, =	441,750	"
Vienna (Prater),	1873, =	2,330,631	"

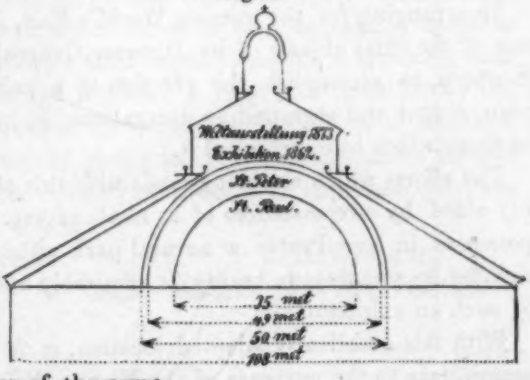
From this tabulation it will appear that the area at disposal for the Vienna Exposition will exceed that of the Paris Exposition of 1867 more than five times.

The three main buildings (Plate I)—the Palace of Industry (1 and 2), the Machinery Hall (3), and the Fine Art Gallery (4)—are, in total dimensions, as well as separately, quite as extensive as the Paris Industrial Palace. The covered space, however, devoted to the Industrial portion of the Exposition can be very largely increased by covering the empty spaces between the numerous cross galleries of the main building.

Without making use of these possible extensions, the covered space included within the three buildings is 108,947 square meters.

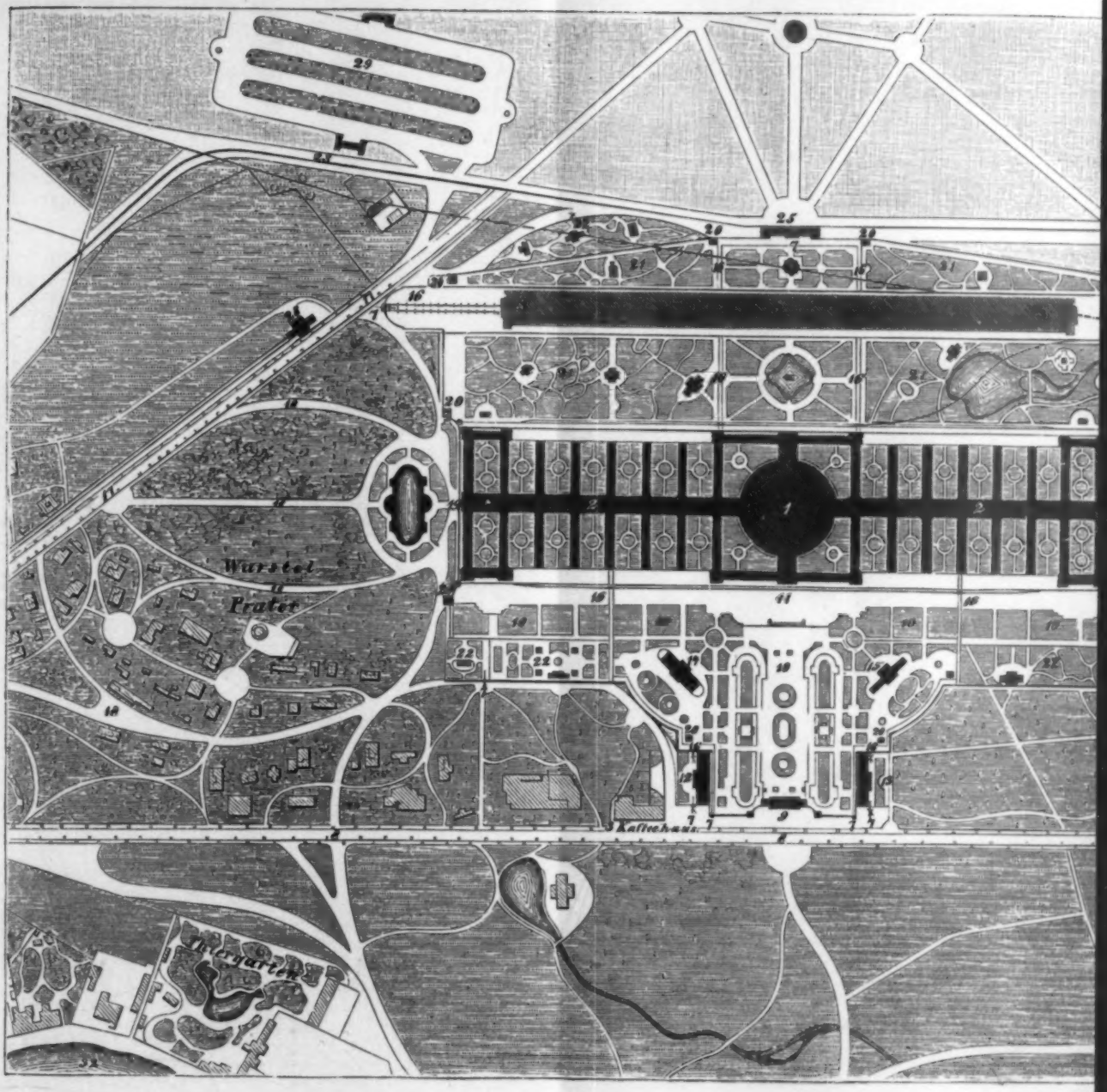
Whether the place devoted to the exhibition in general, is greater or less than those which have preceded it, is to a certain extent of little account, since it is impossible to place the objects on exhibition beneath the free sky; but upon the extent of the covered space provided the success of such an exposition is dependent, for it has regularly been a source of regret that in this particular all previous attempts have been to some extent inadequate to the demand made upon them for accommodation.

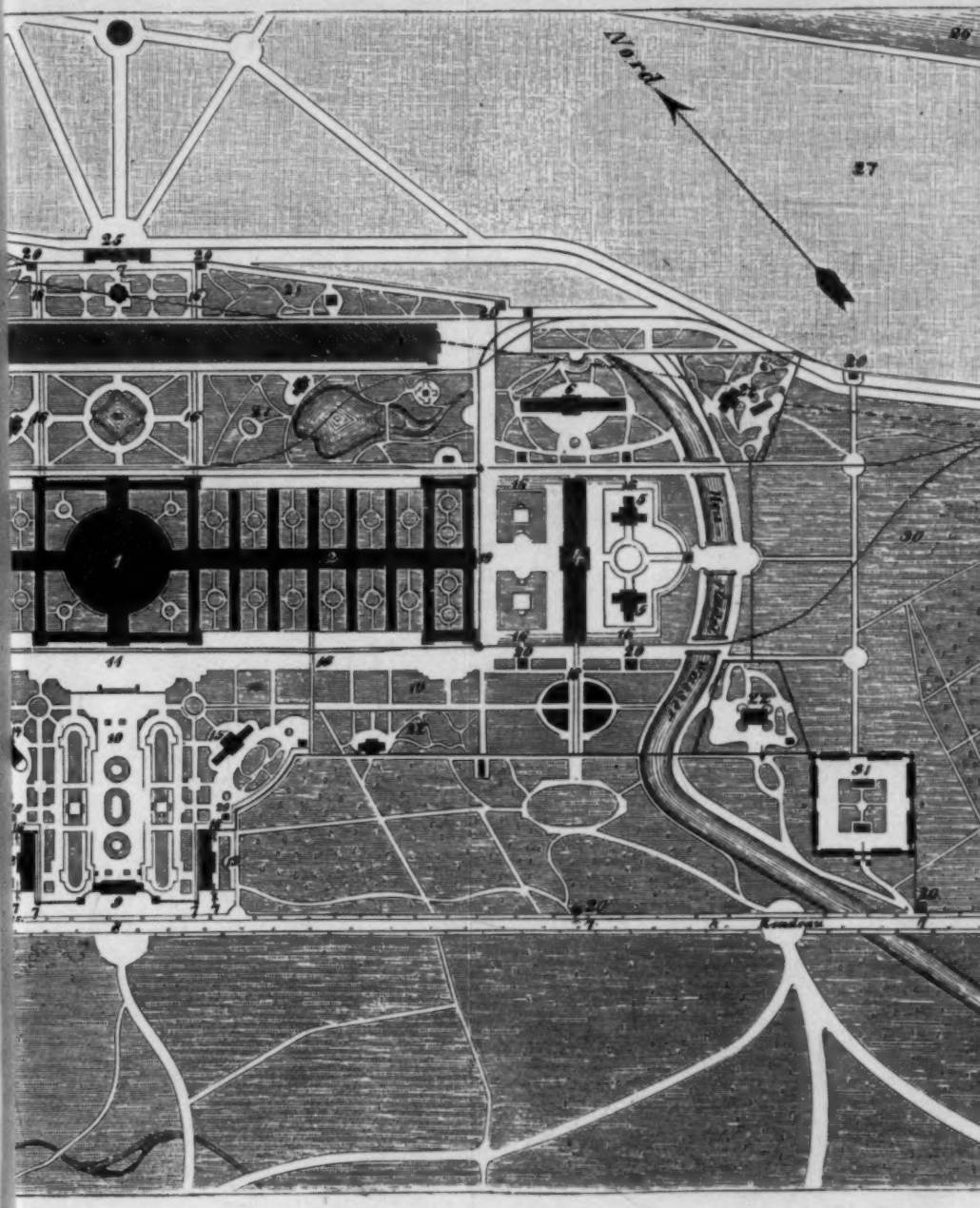
Fig. 1.



The work of erecting the buildings has been entrusted to Mr. Carl Hassendeur, who is likewise the designer of the same.

The great Rotunda (Fig. 1) forms the central point of the great


Wurstel
Prater
Kaffeehaus
Tiergarten


Nord
27
25
1
2
11
Rondeau

l Exposition, Plate I.

building. It was constructed after plans of Mr. Scott Russell, the well-known English engineer—the designer of the Great Eastern and of the Sydenham Glass Palace.

The span of this immense dome measures 108 meters, and it is therefore more than double the size of the greatest in the world, viz., that of St. Peter's, at Rome (Fig. 1).

In order to afford a comparison, the accompanying illustration affords a view of the relative dimensions of the Rotunda at Vienna, that of the Industrial Exhibition building of 1862, that of St. Peter's Church, at Rome, and of the St. Paul's Cathedral, at London; from which comparison a just conception of its magnitude may be obtained.

Concerning the Rotunda itself, your correspondent would as yet venture no opinion, for during his presence on the Exhibition grounds the rafters for the same were not yet laid. To judge, however, from the plan proposed, it may be safely inferred that the funnel shape which it is designed to give it will not make by any means the striking impression which would be formed of one having the classical rounded outline.

Accurately stated, the exterior diameter of the Rotunda is 107·83 meters, and its height 84·1 meters. A rounded roof, supported upon 31 iron columns, 24·35 meters high, rises, with an angle of 31°, to a height of 48·2 metres, and is terminated by a central ring of 30·9 metres diameter. The exterior of the roof is covered smoothly with sheet metal, and, viewed from below, has the appearance of a smooth truncated cone.

Upon this conical roof is placed a so-called Observatory, composed, like the rest of the structure, entirely of iron, the outer diameter of which is 32·4 metres, and the height 10 metres. The roof of this Observatory is made parallel in angle with that of the main roof below, and rises 7·4 metres.

Upon this, finally, there is placed another building, 8 metres in diameter and 18·5 meters high, which terminates in a crown, whose highest point is 84·1 meters above the flooring below.

At a height of 23 meters in the interior of the Rotunda there is placed a gallery, directly against the pillars, having a breadth of 142 meters. This may be reached by two stairways, on opposite sides of the Rotunda, or by two elevators, introduced for the purpose.

The stairway leads upwards to the main roof, from which, by a continuation of the stairway, the gallery in the crown above may be

reached. This second gallery is doubled in such a way that one may inspect from it not only the interior of the Rotunda, but also from another portion of it have a clear view of the entire Exhibition grounds.

The interior of the Rotunda is lighted by windows, brought between the pillars of the Observatory.

The entire space covered by the Rotunda measures 338·8 metres in circumference, and the surface covered by the roof measures 9405 square meters, the interior circumference is 319·6 meters, and the space available for the purposes of the Exhibition and accommodation of the visitors is 8129 square meters.

To give an idea of the forces operating upon the various portions of this structure, a few data are attached.

The vertical pressure upon one of the iron columns of the Rotunda = 109 tons. Pressure on the lower portions of the radial rafters = 211 tons; horizontal strain on same = 181 tons. Tangential strain on the lower roof ring = 863 tons. Pressure on the upper ring, upon which the Observatory rests, = 217 tons.

The total weight of the structure of the Rotunda may be stated in round numbers at 80,000 hundredweight (Zoll centner), or about 4000 tons.

The pillars rest upon béton foundations, which were prepared for this purpose as early as October 30th, 1871.

The delivery of the iron work began upon the 1st of January, 1872; and, according to the terms of contract, should have been completed by Sept. 15th, 1872. At the time of this writing, however, there still remains a portion to be delivered, though the greater part of the work is finished.

Leading from the Rotunda is the main gallery (see Plate I), having a width of 25 metres and a total length of 905 meters. This main gallery is crossed, at regular intervals, with 16 lesser galleries, placed at right angles with the main gallery. These cross galleries have a width of 15 metres and a total length of 205 meters. By this construction there is formed in the two sides of the main gallery 24 courts, or empty spaces, enclosed on three sides, all having the same length as the cross galleries, and a breadth of 35 meters.

These courts permit of an excellent lighting of the entire series of galleries, by high side-lights, and obviate the necessity of constructing glass roofs, to which so many inconveniences attach, particularly in regard to their protection against the rain. They materially aid

in the ventilation of the buildings, and they permit of a very considerable increase in the extent of the buildings, should the necessity for such an increase in dimensions be found necessary.

The whole plan of the Exposition buildings is extremely convenient and simple, and the advantages which it affords in its freedom from complicated passages, &c., and the ready accessibility of all parts of the Palace from without, are unequalled by any previous arrangement for similar purposes.

The impression which is excited by the Exhibition Palace is by no means an imposing one, whether viewed from without or within. It is possible that an opinion expressed at this stage of the work is an unfair one, since the effect of an elaborate and decorated finish may vastly improve the appearance of what now seem like the empty halls of a vast magazine. Perhaps, too, the exterior of the great building may gain vastly when properly finished. The want of light in the interior will, however, be seriously felt, and must be regarded as one of the weak points of the Exhibition arrangements. Your correspondent several times visited its interior, and even with bright sunlight the interior of the vast rooms presented a dusky, dismal appearance (Plate II).

From an architectural standpoint, Hafenauer has divided the Palace into three parts—one large quadrangular main building, the centre of which is formed by the Rotunda, and two end buildings, enclosing the rectangular courts before alluded to.

Besides the 32 entrances to the buildings on the sides of the cross-galleries, there are four grand portals, of which one is designed for the reception of the visitors coming to the grounds by way of the Prater-allee (8), and one for those arriving through the Feuerwerks-allee (17).

Behind the Palace of Industrie rises a long building, almost equal in length, the Machinery Hall (3). In this it is designed to expose to the visitors, in full operation, the machines which are exposed for exhibition.

This building has a length of 800 meters, and a breadth of 49·6 meters.

A cross section of the hall is shown in Fig. 2. Two railway tracks are laid at the sides of the central portion of the hall, and pass through its whole length.

Four rows of pillars carry the rails for a number of transporting cranes, and serve at the same time as the points of attachment for

the two main driving shafts, which run through the whole length of the hall. As may be drawn from an inspection of the illustrations, the machinery hall does not present in its architectural design any

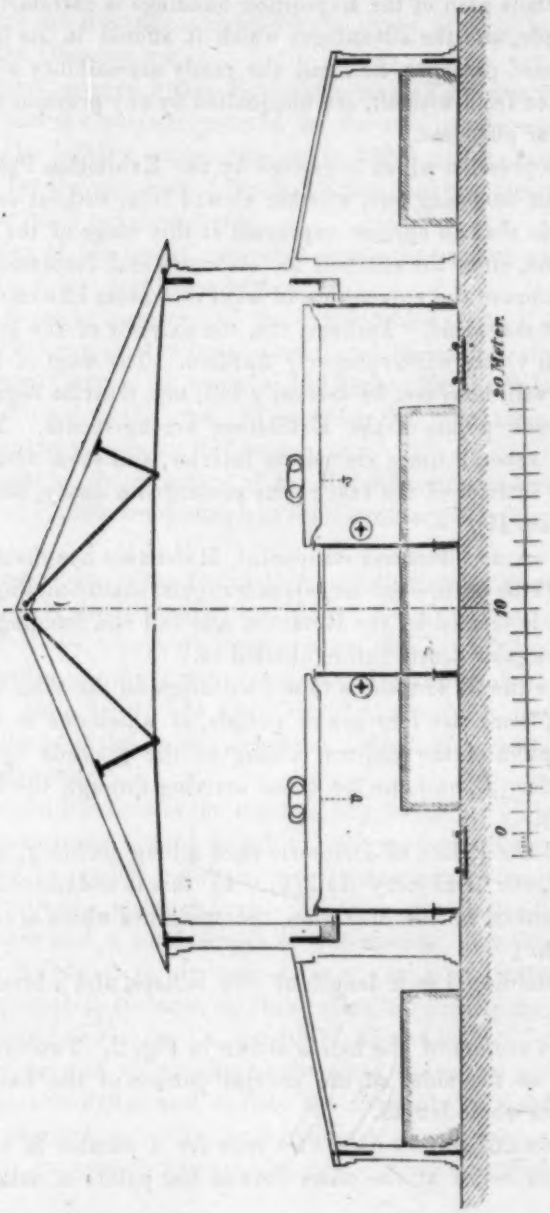


Fig. 2.

particular points of interest; it likewise appears to lack in that essential so badly needed in the great building, namely, a sufficiency of light.

The main nave of the Machinery Hall is large enough to permit of the display of an operation of machinery of moderate height; the side naves, on the contrary, afford but small and confined spaces for the same, and it is difficult to understand why such a disadvantageous arrangement of space for a world's fair could have been projected.

The mechanical and engineering portion of the Exposition is under the superintendence of the Court Councillor, von Angerth, as Chief Engineer. To aid in the proper carrying out of the objects of this portion of the work, there have been associated with him Professor von Grimburg, in the department of machinery, and Inspector Heinrich Schmidt, in the department of engineering.

Opposite the south end of the Palace of Industry is located the building devoted to the Fine Art department of the Exposition—a four-naved building, along the middle portion of which is a double row of large saloons, lighted from above, for the display of larger pictures. On both sides of these central saloons are arranged smaller halls, with side-lights, designed for the display of pictures of less size.

The space between the Fine Art Gallery and the Palace of Industry will be taken up by the display of statues and other objects of art; while the grounds will be converted into a park, to add to the pleasing effect of this branch of the Exposition.

Adjoining the Fine Art Gallery, and connected with it by a covered corridor, are attached two pavillions, for the exhibition of the collections of amateurs—an idea of the General Director, Baron von Schwartz-Senborn; which, if properly realized, will add to the treasures of this department the riches of numerous private collections, and greatly enhance its value to lovers of art, and in an educational point of view.

Upon one side of the Fine Art Gallery is placed a large conservatory, and upon the other an aquarium.

Between the main avenue of the Prater and the Palace of Industry the grounds have been converted into an elaborately decorated park (10), at the sides of which the visitor will observe a number of pavillions, of which one is appropriated for the use of the Imperial Commission having the Exhibition in charge (12), another for the postal and telegraphic service (13), a third for the judges (15), and a

fourth, furnished in the most magnificent style, is set apart for the use of the Imperial Family (14).

Numerous covered ways, branching right and left from the main entrance, are provided to meet the possibility of wet or unfavorable weather, so that the public may enter and leave the Exposition grounds with every convenience. The space between the Palace of Industry and the Machinery Hall, as well as to the Fine Art Gallery, is similarly protected by covered ways.

The portion of the park lying between the Palace of Industry and the Machinery Hall (21), is designed for the exhibition of various works of architecture.

Below the Art Gallery an arm of the Danube, spanned by three bridges, separates the Exhibition grounds proper from an extensive park (30), which, in connection with the broad Danube embankment beyond (27), is designed to serve for the exhibition of agricultural implements, horses and cattle.

The embankment named above will also be used for exhibiting the operation of hydraulic machinery and apparatus.

The methods of intercommunication are both numerous and complete.

Two railways—the Northern Railroad (23), and the State Railroad (24)—will carry passengers, at all hours of the day, to the depot (25), behind the Machinery Hall, and in addition steamers will ply upon the Danube (26), to the Exhibition grounds.

It had also been designed to facilitate the transportation of the daily crowds of visitors to and fro from several portions of the extensive grounds by introducing tramways, to be operated with a wire rope and clip pulley, but, unfortunately, this plan appears to have been abandoned.

The several horse railways will likewise extend their tracks to within a short distance from the Exhibition buildings.

The accommodations arranged for carriages and other conveyances (29), are very extensive, and include space enough for about 2000.

It may, therefore, in view of what has been presented, be confidently expected that the contemplated Exposition in Vienna will in no wise prove to be inferior to those which have preceded it.

For the various mechanical industries, the following special information concerning the display of machinery may prove of interest:

Special Regulations concerning the Exhibition of Machinery.

1st. The Machinery Hall is intended for the exhibition of objects included under Group 13 (Machinery and Devices for Transportation).

From this department is excluded such machines as will by their operation annoy the visitors, or such as would injure the other objects on exhibition, or any which in the judgment of the direction interfere with the greatest good of the greatest number. The exhibition of such excluded machines can only take place without the Hall, in the open air, or within a covered space erected at the expense of the exhibitor.

2. Exhibitors of machines and apparatus are required to state—

(*a*). The space required by them, in meters, both in length and breadth.

(*b*). The amount of wall space required, as before, in meters, indicating both breadth and height.

(*c*). The power required to run their devices, stated in actual horse-power, or in kilogramme-meters.

(*d*). The required quantity of steam, stated in kilogrammes or cubic meters per hour, and the steam pressure in atmospheres.

(*e*). The required water supply, stated in cubic meters per hour.

(*f*). The required gas supply, stated in cubic meters per hour.

3. The Foreign Commissioners to the Exhibition are requested to report to the General Director the extent and nature of the machinery to be set in operation, by the 1st of August, 1872, at the latest.

4. Machinery and other devices for exhibition will be admitted into the Machinery Hall from the 1st of February, 1873, until the 15th of April, 1873, and must be completely arranged for exhibition or operation by the 25th of April, at the latest.

Machinery or apparatus which are sent in parts, and are composed of large and heavy pieces, are required to be erected by the 15th of April, at the latest.

Walled foundations must be erected at the cost of the exhibitor, and are required to be finished and ready for the reception of their appointed machines by the 15th of March.

5. In the interior of the Machinery Hall, and round about it, railways have been provided, so that the objects to be exhibited can be transported to the immediate neighborhood of the place set apart for them.

6. Upon these tracks a number of cranes will travel, which are designed to aid in the unloading and erection of the machinery.

In addition to these, travelling cranes on elevated roadways will be provided for the same purpose.

7. The flooring of the machinery hall will be of unusual strength and solidity—so that even very heavy machines may in most cases be erected directly upon it without special foundations.

8. The power needed to set and keep in operation the various machines on exhibition will be furnished free of cost by the administration of the exposition. The arrangements for obtaining supplies of steam, water or gas, from time to time, must be made with the general director.

9. The power will be distributed by two horizontal driving shafts. These shafts are 0.09 meters in diameter, and make 120 turns per minute. They are placed 4.5 meters above the flooring, and are supported appropriately from the pillars of the building. (The position of these shafts may be seen by inspecting fig. 2).

10. The exhibitors are required to provide, at their own cost, the driving-pulleys for the main shaft, as well as all other parts, such as pulleys and belts, which may be required to operate their machines.

The driving-pulleys must be made in two parts, to permit of being attached to the shaft. The attachment of these pulleys must be so effected as not to injure the shafts.

11. All machines which are intended to be set in operation must be placed in the central division of the machinery hall. In addition to this, the machinery of the several countries represented in the hall must be placed side by side in such a manner as to form one uninterrupted series. The driving shafts will only be extended so far as may be required by the grouping. The maximum amount of shaft-length to be assigned to the various nationalities will be made known to the respective commissioners on the 31st of August, 1872.

12. The preservation, cleansing and lubrication of the main lines of shafting will be undertaken and attended to by the authorities; but exhibitors are expected to look after the preservation, cleaning and lubrication of the machinery, pulleys, belting or other gear employed by them.

13. Should machines be presented for exhibition, designed to be shown in operation, which cannot be driven from the main line of shafting above, subterranean or other mode of transmission will be supplied for these cases, if deemed sufficiently important to warrant such unusual attention.

14. Where machines presented for exhibition require to be operated outside the machinery hall, special arrangements will be made in each case by agreement with the exhibitor.

15. The daily working time during which the machinery may continue in operation will be announced by the authorities before the opening of the exposition. The exhibitor is required to provide the attendants he may need, to run and keep in order the machines he may present for exhibition; for no person except those specially provided by the exhibitor will be authorized to touch or set in motion any machine.

16. All machinery in motion must be isolated by a railing, or some similar arrangement, in order that visitors may be suitably protected from possible injury.

17. Machinery and apparatus designed to serve specially the wants of the exposition, may be delivered to the authorities for the purpose, and will be classified under group 13.

Amongst these machines there may be classed the following:—

(*a*). Steam boilers for generating power for the machinery.

(*b*). Steam engines for driving the shafting in the machinery hall.

(*c*). Gas machines or water power machines for operating special machines, or pumps of machines.

(*d*). Pumps, large and small, for affording water supply.

(*e*). Hoisting cranes for aiding in the manipulations of the machinery hall.

(*f*). Travelling cranes, with a gauge of 10.5 meters from centre to centre of the rails, for transporting and erecting heavy objects and machines in the machinery hall.

(*g*). Hydraulic machinery.

(*h*). Locomotives to be employed for the purposes of the exhibition without the hall.

18. The exhibitors of machinery or apparatus to be devoted to the special uses of the exhibition will be allowed special privileges; but in every case these privileges must be arranged by agreement with the director general.

19. The machines and apparatus handed over to the authorities to serve the purposes of the exposition will be specially tested by them.

Steam boilers will be tested as to their consumption of coal and their steam generating capacity. Steam and gas machines will be tested as to their power by indicator or dynamometre tests. The re-

sults obtained by these tests will be made public upon report of the exhibition.

For the convenience and to meet the possible want of the exhibitors, a workshop, furnished with the several standard machines for turning, cutting and shaping metal, will be attached to the machinery hall. In this workshop such small work and repairs as may be needed by exhibitors can be done, in accordance with regulations imposed by the authorities.

The administration of the workshop will be under the control of the authorities, and price of the work there done will be regulated according to a tariff arranged by the authorities.

Besides these regulations for the special administration of the machinery department of the exposition, the general regulations will be likewise enforced.

The General Director,
BARON VON SCHWARTZ-SENBORN.

Very truly yours,
WILHELM H. UHLAND.

GEOLOGICAL SURVEY OF PENNSYLVANIA.

To His Excellency, Gen. J. F. Hartranft, Governor of the State of Penna.

PHILADELPHIA, February 1, 1873.

SIR:—You have done me the honor to say that, if I have any information likely to be useful in proposing a geological survey of Pennsylvania, you will be pleased to receive and consider it.

I reply, that all well educated persons now recognize the importance of increasing human knowledge, believing not only that there is no limit to be put to this increase, but that every kind and quality of knowledge is, or will be, in some way or other, useful. Uneducated people find it hard to assign value to what looks to them abstract and unpractical, but business men who have had most experience and the best success in life, comprehend pretty well that the collection of natural facts and the discovery of natural laws are the foundations of civilization and the causes of American prosperity.

To collect facts and to arrange them for discovering laws of nature is an expensive and painful occupation. It is the business of men trained for that purpose; apart from the common transactions of mercantile and manufacturing society; unremunerative, and demanding the patient industry of the whole man, throughout his whole life.

And many such trained minds must work together to accomplish results useful to the Commonwealth. This is true for every kind of scientific work. It is especially true of geology.

It is not generally known how entirely the buying and selling of mineral lands depends upon the private surveys and reports of professional geologists of established reputation for knowledge and truthfulness. Mining enterprises of respectable size are never undertaken now without first obtaining from some competent geologist a careful statement of his observations and advice; precisely as no railway is now built except upon the well considered report of an experienced Civil Engineer.

But these advantages are monopolized by the few who are able to pay for such surveys. A State geological survey is therefore essentially democratic in its nature, having for its object to prevent monopoly, and to publish such knowledge to all the citizens of the Commonwealth without regard to fortune. Knowledge which is bought at such high prices by wealthy landholders and incorporated companies *must* be desirable for all the farmers of the State; for the householders and trades-people of all its towns and villages; for every manufacturer and artisan. however modest may be the part he plays in the business community. A survey costing annually $50,000, or $100,000 per annum, furnishes to the population of Pennsylvania, at the rate of five or ten cents per voter, information for which energetic speculators, large land-owners, and wealthy manufacturers are constantly paying from $500 to $2,000 apiece. And having paid such high prices for it they naturally keep it to themselves. Whereas the interests of the Commonwealth demand that it should be published to all citizens.

But a still stronger argument for a State Geological Survey comes from considering that geological knowledge requires the widest range of facts to make it reliable. There were many observers of the weather and good local weather prophets before the establishment of the Weather Service Bureau at Washington, two years ago. But no real knowledge of the weather was ever got by these private observers, sufficient to predict the great waves of cold and heat and wind. It required a Government survey to accomplish this.

Just so, the local geology of this or the other man's property would be pretty much all costly guess work, but for the State Geological Surveys of 1836—1841, and 1852—3. That great work sketched out the general geology, studied details of the most important dis-

tricts, put the parts and fragments together, established rules and probabilities, recorded average measurements, and trained the professional geologists who, ever since then, have been surveying properties for mining, smelting and railway interests. The first mineral State of the Union would be in a pretty situation to-day but for that State Geological Survey; much such a situation as a great warehouse without ledgers and clerks.

Twenty years have passed since the Geological Survey of the State ordered by the Legislature was ended. It is surely high time to recommence.

The first survey was in most parts of the State very imperfect. Parts were carefully surveyed and well described; but whole sections, now among the most important, were merely sketched out. These require accurate surveying and description. In a word, the first survey was, in the very nature of the case, and at that early day, merely preliminary to a better and future one. This better survey ought now to be undertaken.

I will insist no longer on the need of a Survey, but proceed to consider its character.

The points of most moment are as follows:—

I. Good maps are the basis of all useful research in every department of science and the arts, and especially in the political science of statistics, and in the practical sciences of geology and metallurgy. The geologist's work must be inaccurate and costly to his employers and to the community wherever no good map has been made of the ground. The first step of our geological survey ought to be the construction of a perfect map of the State; or at least of those parts of it which are to be first studied geologically.

We have sufficiently good maps of a number of counties. But the counties of the northern, middle, western and south-western counties have no maps which are of the proper value to a survey. These should be mapped with road odometer surveys, as fast as practicable, taking them up in the order of their geological importance. Meanwhile the United States Coast Survey will obtain for us the absolute determination of one fixed point in the centre of each county; and triangulate for us, or at all events, greatly assist us in triangulating parts of the State on a sufficiently large, rapid and cheap scale to enable us to rectify and connect the county maps into a whole.

I have the assurance of Prof. Pierce, Chief of the Coast Survey, of the great interest he takes in our State Survey; and he is now con-

necting the shore lines of the Coast Survey across the continent; which connection will take place partly through Pennsylvania.

I deem it inexpedient to call for a new State Map at first. That will grow out of our County Surveys, and must wait for the astronomical and telegraph-time work; whereas the county odometer surveys can go on at once and rapidly. Two men (*i. e.*, a surveyor and his rod man) can survey a county in a year at an expense of about $3,000, or $2,500. We have very good practical county surveyors about the State; and if we had the money we might have a County Map of every county in the State by this day two years hence. But a surveyor should know something about geology; and the training which our county surveyors and their boys will get by this connection of road running with geological surveying ought to be one of the strong arguments in its favor. A geological survey when continued from year to year becomes a great and powerful school for several kinds of people, increasing their public usefulness in their professions and employments.

I should advise the mapping of five or ten counties per annum. When Robert Smith, the map publisher, had expended $80,000 in mapping most of the counties of New York, he applied to the legislature of that State for aid to map the remaining wild counties where he could get no subscribers, in order to collate and publish a State Map. This was done by an act requiring every school district to purchase a copy or copies of the State Map and, I believe, of the county maps also. The cost of the work was more than covered, and at the same time the full publication and useful distribution of the State Map was secured.

The single counties ought to be published on a small scale as fast as made; and geologically colored as fast as studied. One uniform scale and size of page should be adopted, so that a handy atlas would be the final result. Cheapness and accuracy rather than artistic finish ought to be aimed at; the latter can be attained after the general wants of the public are satisfied. With our present art of printing and photographing, every man and child ought to have a colored geological and geographical (topographical) map of his own county (with a small scale map of the whole State) put into his hands for a few dimes; and that of the highest scientific correctness and completeness.

The model for a publication of this sort is a handy and handsome octavo Atlas of the Geology of England, in 33 colored plates, inclu-

ding a plate of England, and one of Scotland, the rest being plates of one county, or two adjoining counties, with every town and hamlet, small stream, road, railroad and park exhibited with perfect distinctness; the geological formations being colored over all. It seems impossible to improve on this book. It is sold very cheaply and is in the hands of a great many tourists and commercial travelers. It is prefaced with 16 pages only of geological explanations, including "Agricultural Geology and Water Supply." The maps of the Geological Survey of England formed the basis of this beautiful little atlas of Reynolds. And without the government surveys this useful popular manual would have remained an impossibility.

I consider the large and unwieldy county and local maps published by some of the State Geological Surveys of the United States mistakes. Everything needful can be shown on a smaller scale, with equal accuracy, and far greater convenience to the reader, tourist, and student in the field; with large saving of expense to the State.

The main point to be insisted on is the desirableness of laying the results before the public in a useful and accurate but cheap form; and as fast as the work advances, without waiting for the difficult and tedious compilation of an entire State Map.

Absolute perfection in science is unattainable. However accurately work may be done, still greater accuracy will be possible; however complete a long and patient study of a region or locality may make our knowledge, longer and more accurate study will always still further improve our knowledge. The very name of *Final* Geological Report should be abandoned. It is an absurdity. It has seduced ambitious men into a policy of postponing the publication of their researches long after a mass of most useful information for the public has been collected; for fear that errors have been committed, important details been overlooked, and their personal reputation may thereby be endangered. The right policy of a State Geologist, or of a State Geological Corps of Geologists, is to hand over to the public all reliable information as fast as obtained; as fast as consistent with conscientious carefulness.

I would urge, therefore, the prosecution of our State Survey by districts; and the publication of its maps by counties; in a cheap but handy uniform shape; to make an atlas which should grow in size from year to year. Of course the most important and the least understood districts should be surveyed and published first.

II. While a Geological and Metallurgical Survey of the whole State

has been demanded by the general voice of the business community, and for the land ownership of all parts of the Commonwealth, it is especially needed in the oil regions of the northwest counties, in the new bituminous coal basins of the western part of the State, and at the iron smelting and rail purchasing centres.

There are whole districts of the State's surface which remain as yet to a large extent unstudied by competent geologists pursuing the best method of research. There are problems of structure and deposit involving millions of dollars of value still unsolved, which nothing but well developed instrumental field-work can solve.

The old survey did a great work. It clearly portrayed the main features of the State. It told us exactly where to look for what we want to find. It has given us a very magnificent sketch, which we may now fill up. The new survey will not cost half as much, in time and money, as it would have cost had no previous survey been made. But when the survey was made in 1836—1841, there were no county-maps; no State map but Melish's, which was full of errors in the best settled counties, and good for nothing in the back counties; and almost no good exposures of our mineral veins except in the anthracite coal basins and around Pittsburg. Now, the soil is everywhere full of trial shafts and trial explorations; the forests have been extensively cleared; roads penetrate what were then inaccessible districts; railroad lines and branch lines have covered whole counties with instrumental field-work; twenty thousand oil and salt wells have been bored; hundreds of mining properties have been put into working order; the population of the State has grown intelligent, observant, and enterprising; and the scientific and practical skill of geologists, metallurgists and surveyers has reached a high pitch. We are now able and ready to grapple with the many difficult questions of number, order and quality of our coal beds; where they run, how they lie, how they can best be mined, and how best connected with market. We are prepared to get full and accurate information about the oil, to show on maps the extent of the oil regions, and the depths to which borings must be sunk. We are, above all, ready and able now to take up the iron problem of the State, and find out the law of the deposits of the brown hematite ores.

III. I have stated the wants of the present generation. The next has also claims upon us. A most important function of a geological survey is to *preserve* knowledge *for future use*. Science is cumulative. It makes slow and painful advances. It is obliged to collect

an abundance of facts before it comes to true conclusions. Pennsylvania has lost enormously during the last twenty years by having no bnreau of statistics, no corps of observation and publication, to observe and preserve, collate and relate the facts of its geology and mineralogy as they have made successively their appearance. No Commonwealth can afford to be without such an apparatus for preserving from loss and forgetfulness the discoveries and investigations of private persons, even for one single year of its existence. Thousands of most valuable facts have been lost to us during an interval which cannot be recovered. How many openings on coal veins are now covered up, no one being able to give any reliable information about them! Twenty thousand oil borings have been made, and not one hundred of them are on record, if discoverable. Hundreds of gangways have been driven and abandoned, and cannot now be studied; many of which would disclose the nature of faults and disturbances which affect neighboring properties, and overlying and underlying beds not yet worked, where certain knowledge is preserved to govern the future mining engineer in his plans for getting at the mineral. He must work as completely in the dark as if his knowledge had never been got, and often paid for at a ruinous expense. The sooner a geological survey is established the better for the *future* interests of the State as well as for its present necessities.

IV. Geology and Mineralogy must carry on work in several different departments at the same time. A mapping office, a chemical laboratory, and a museum of minerals and fossils are necessary to good field-work. The field-work must be done by three kinds of experts working in harmony and mutually assisting each other: surveyors, geologists and palæontologists, or fossil-shell and plant students.

A complete working corps, therefore, should consist of:—

1. A chief or director who is familiar with both topography and geology.
2. A chemist, who must be also a good practical mineralogist and metallurgist.
3. A palæontologist who knows vegetable as well as animal fossils.
4. Assistants in the field to head surveying parties.
5. Assistants in the laboratory and museum.

But a survey of a great State like Pennsylvania cannot be carried on well without a still greater division of labor. For the sciences are now so extensive and difficult that their greatest experts are obliged to limit themselves to one department of one science. I should propose

therefore, if my advice were asked, some such organization as the following:—

1. A Director of the Survey, who shall take charge of the maps and the field-workers, the illustrations and publications of the Survey.

2. A Chemist with his laboratory.

3. A Palæontologist in charge of the museum.

4. A Fossil Botanist to study the coal beds in all parts of the State, in the field.

5. An Assistant Geologist in charge of the Oil Regions.

6. An Assistant Geologist in charge of the topography and structure of the Bituminous Coal Region.

7. An Assistant Geologist in charge of the Iron Ore Regions of Middle Pennsylvania.

8. An Assistant Geologist in charge of the revision of the Anthracite Coal Regions.

9. An Assistant Geologist in charge of the Primary (gold and chrome bearing) rocks of the Southeastern district of the State, and one acquainted with the extension of this important belt of rocks through the Southern Atlantic States.

10. Men employed under the above, to handle instruments when necessary, make collections, draft maps, copy original documents, &c., &c.

It is no economy to employ inferior talent. Mistakes committed by inexperienced and incompetent persons produce not only present waste, but permanent mischief. Men of the best standing in the science would be eager and proud to take part in so great a work.

Young men trained in American and European Mining schools, are waiting to be employed as assistants. We are assured of a large amount of valuable *voluntary* assistance from the members of the Academy of Natural Sciences and from persons in various parts of the State. The Collegiate institutions at Easton, Bethlehem, Lancaster, Pittsburg and other towns would be zealous to co-operate.

V. But men with families to care for must receive an adequate support. Commonly, the lives of such individuals have been spent in the unremunerative acquisition of knowledge, skill, experience and materials, which is only now bearing its natural fruit, enabling them to provide against the inabilities of age. The State should pay well for the best talent, where so much mischief might be done by incompetent persons. A State Geological Survey should not be made a mere stepping-stone to something better, or an advertisement for lucrative private professional work. There ought to be nothing better.

All traveling and carrying expenses ought to be borne by the Survey, and not to come out of the salary of the geologists and assistants. Such expenses can be reduced to a minimum by a candid application to railway companies, who will grant free tickets to the working corps of the Survey; and free transport for their collections. Great hospitality has always been shown to geologists on a public survey by all classes of people. There will still remain expenses which cannot be avoided; but a considerable portion of these fall on the first year of a survey; for instance, the purchase of field instruments and wagons, which are absolutely necessary for a proper and rapid exploration of any district of the State, whether cultivated or wild.

If you desire to know what idea of the cost of a State Survey my experience of such work for nearly thirty-five years enables me to form, I reply, that the cost will be commensurate with, first, the thoroughness and, secondly, the rapidity of the work to be done. The following may perhaps stand as a fair approximation to the truth :—

ESTIMATE OF ANNUAL COST OF STATE SURVEY.

Director,	$5,000	
Chemist,	3,000	
Two Palæontologists,	3,000	
Assistant in Oil Region,	2,000	
" " Bituminous Coal Region,	2,000	
" " Iron Ore Region,	2,000	
" at Pottsville,	2,000	
" " Wilkesbarre,	2,000	
" in Southeastern Pennsylvania,	3,000	
		$24,000
Laboratory (for first year only),	2,000	
Chemist's Assistant,	1,000	
Field party for Oil Region,	3,000	
" " Bituminous Coal Region,	3,000	
Rent of house for Museum,	1,000	
Assistant in Museum,	1,000	
Incidental expenses,	500	
Traveling and Transport expenses,	1,000	
Instruments and Vehicles (first year),	1,500	
		$14,000

PUBLISHING DEPARTMENT:

Draughtsman, ...	3,000	
Lithographing and Wood-cutting, Printing, Binding and Distributing the Work of the Year, with Maps and Illustrations (say 1000 pages 8vo., 10 maps and 100 wood cuts), 5000 copies, .	6,000	
		9,000
Total, ...		$47,000

By including the item of publishing in the estimate we should avoid delays at the close of the year, and make each year's work complete and finished up to date; giving the legislature opportunity to pass judgment on the work, while the public are not kept out of the use of the results as fast as they are obtained.

I do not include the triangular and astronomical determination work in the estimate, because I believe I have Prof. Pierce's assurance that the Coast Survey will relieve the State from this burden to a considerable extent.

I can think of nothing more at present to suggest, and beg you to excuse the great length to which this subject has protracted my letter.

Your obedient servant,

J. P. LESLEY.

P. S.—If the mineral wealth of Pennsylvania is to be properly exhibited at the Centennial Anniversary, a better method of accomplishing this result could not be devised, nor one so cheap, as by the organization of a State Geological Survey.

Consuming Coal Smoke.—Mr. T. B. McCarty has recently been awarded letters patent for a method of producing an increased draft, and of securing a smokeless fire by the use of steam. To carry out his system, the inventor proceeds as follows:—A small pipe conveys dry steam from top of boiler to the upper part of the furnace, where it enters in two small jets, striking downward on the burning fuel. A description of the working of the plan here given states that no sooner is the steam injected into the furnace, than a sluggish, smokey fire springs up into a clear bright yellowish and intensely hot flame, filling the whole furnace with a loud roar.

ON THE COMPOSITION OF ANCIENT CEMENTS AND ROSENDALE CEMENTS.*

By Arthur Beckwith, C. E.

The cements commonly used in New York and elsewhere for ordinary constructions, as well as for large engineering works, have frequently elicited the interest of inquirers into their nature and properties.

Among the best descriptions of the qualities of these cements we may cite General Gillmore's work on the subject, in which we find a list of valuable experiments which set forth the properties of various cements, and also a table showing the chemical composition of a number of cement-stones from which our cements are made.

These experiments and tables do not, however, contain the chemical analysis of the cements themselves, upon which so much depends.

The chemical analysis of several of the Rosendale cements has lately engaged my attention, but before setting forth the results obtained I will recall briefly the history of our modern knowledge of cement.

The monuments of Egypt present one of the oldest examples of the use of lime for constructions. The mortar which joins the stone of the Pyramid of Cheops is precisely similar to modern mortars made of sand and lime. In limiting the use of mortar to filling narrow joints which separate immense blocks, and thereby reducing almost to insignificance the part which it had to play, the Egyptians seemed to forestall the influence of a dry and burning climate. Time has justified their prudence in this respect, for the works erected on the banks of the Nile by the Romans, made of small materials and presenting many joints, have left but faint traces, whilst some Egyptian temples still present themselves intact to our admiration.

Unqualified praise has often been given to the excellence of Roman mortar, and the belief is sometimes expressed that all we can hope to do is to regain the secret of making mortar once possessed by the Romans. It is a common remark that "Roman mortar has lasted for eighteen centuries, whilst a number of modern buildings are in a deplorable state of preservation."

To make a fair comparison, we should, however, only cite similar constructions, and then we are comforted by these words of Pliny: "The cause which makes so many houses fall in Rome, resides in the bad quality of the cement."

* From the Proceedings of the American Society of Civil Engineers.

The knowledge of the properties of lime descended from Egypt to Greece, where the exigencies of the climate and the ingenuity of the people brought forth many of its uses, unknown to Egypt.

Subsequently Greek colonies imported and popularized their processes in Italy; and Roman architects, like Vitruvius, cite the names of Greek authors on the art of construction. Their names alone have come down to us, but Vitruvius had full access to them, and in our inquiry after the knowledge of mortar possessed by the Romans, it is to him that we must refer for information. Indeed, he has left us a detailed table of precepts used by the builders of Greece and Rome, which do not justify our unreserved admiration; everything relating to lime, sand and pozzolana is clearly treated therein.

We may safely affirm, with Vitruvius, that the Romans made use of the lime, sand and materials of the countries where they built; that they considered the best lime to be produced from hard and pure marble, *i. e.*, the fattest lime known; that in Italy they mixed it with pozzolana when used for hydraulic purposes, and that out of Italy they replaced the pozzolana from Vesuvius, by powdered brick or tile.

Roman mortars, when examined to-day, are found to bear a distinct resemblance to each other; they may be recognized by the presence of coarse sand mixed with gravel; lumps of lime are so often to be met with, that incomplete slaking will alone account for them. Mortars laid in damp spots for cisterns and pavements were composed of bricks in small fragments mixed with fat lime; this concrete required to be compacted by pounding and left to dry—the surface was then scraped, polished and painted—evidently to prevent the dissolution of lime by water.

It will be seen by this that what we term hydraulic lime, and also the modern product of cement, were unknown to the Romans.

It is important to refute the belief that methods may have been known to them of which we have lost the secret. When the decay of arts followed upon the downfall of the Roman Empire, houses nevertheless continued to be built, and the familiar processes under the eye of the workman must have been transmitted from father to son. So true is this, that to-day Italian masons, who certainly have not read Vitruvius, make coatings for cisterns and concrete floors in the very same manner as may still be seen in the ancient ruins of Rome.

Neither is it true that Roman mortar is uniformly good. Its strength of cohesion varies in different examples from 35 and 85 lbs. per square inch to 100 and 160 lbs., or as much as 500 per cent.

In the middle ages a volcanic conglomerate from the banks of the Rhine, named traass, was substituted for the pozzolana of Italy, and mortar was made of fat lime, mixed with traass, to render it hydraulic.

Many castles erected during that period stand well to-day; the well-known castle of the Bastile, erected in 1369–83, which after withstanding a siege required the use of powder for its destruction in 1789, was found to be extremely solid even in the interior walls.

It would seem, then, that the secret of the Romans was known also in those times, and could have been lost only at the Renaissance, when least of all such a supposition is probable.

At what period were first used certain limestones, having the property of producing a lime which will harden under water, is not precisely known; the first use of cement stone is equally obscure.

In 1796 Messrs. Parker and Wyatts began to manufacture from egg-shaped limestones found near London, a product known later as *Roman Cement*, and which was soon received with great favor throughout Europe; but neither the producers nor the consumers offered any explanation of its merits.

Not until 1818 and the following years was the true explanation given of the hydraulic properties of limes and cements, when Vicat published his discoveries.

Before that, in 1756, when Smeaton was preparing the arduous and bold construction of the Eddystone Lighthouse, this celebrated engineer examined with scrupulous attention the natural hydraulic lime of Aberthaw. Treated by acids it left a residue "which appeared to be a bluish clay, weighing about one-eighth of the total weight of the stone."

In 1786, Saussure attributed the hydraulic properties of some limes of Savoy to the combined influence of manganese, quartz, and even clay; but he left his opinions in the mere state of conjectures.

Finally, Descostils, in 1813, having discovered a considerable proportion of finely divided silica in the lime of Senonches, attributed the well-known hydraulicity of that lime to the silica it contained.

But the conjectures of Smeaton, of Saussure and of Descostils were vague; they rested upon no proofs, and found no applications in practice.

The discoveries of Vicat attained their immediate object, for in a short time artificial hydraulic lime of excellent quality was manufactured on a large scale under his direction, and a few years later he indicated as many as 400 quarries in France where hydraulic limestones were to be found.

Moreover, the mortar made from his hydraulic lime equalled in hardness at the end of eighteen months the hardest ancient Roman mortars.

It is unnecessary to recall the evidence by which Vicat demonstrated —by analysis and by synthesis—his great discoveries. No one questions to-day the fundamental truth, that the properties of hydraulic limes depend upon the proportion of clay disseminated throughout its tissue, and that clay by being calcined acquires the property, like pozzolana or trass, of rendering fat limes hydraulic, when thoroughly diffused throughout their mass.

The labors of Vicat and Berthier have led to the following classification of limes and cements, and consequently of limestones and cement-stones:

Table of Classification of Limes and Cements.

Proportion of clay in the limestone.	Proportion of clay in the product.	Class of lime or cement.
Less than 10 per cent.	Or less than 17 per cent.	Fat and non-hydraulic limes.
From 10 to 15 "	From 17 to 24 "	Slightly hydraulic limes.
" 15 to 17 "	" 24 to 27 "	Hydraulic limes.
" 17 to 20 "	" 27 to 30 "	Eminently hydraulic limes.
" 20 to 23 "	" 30 to 34 "	Limit of hydraulic limes.
" 23 to 30 "	" 34 to 43 "	Beginning of cements.
" 36 per cent.	" 50 per cent.	Good hydraulic cements.
" 40 per cent.	" 54 per cent.	Hydraulic cements of diminishing value.
" 60 to 90 per ct.	" 73 to 94 per cent.	Pozzolanas.

A point which bears directly upon our subject is the fact of the existence of a limit for the proportion of clay, at either end of the scale of cements. The transition from the properties of hydraulic lime to those of cement is not gradual, but sudden. Thus a limestone containing 20 per cent. of clay will produce an eminently hydraulic lime, but if we increase this proportion to 23 per cent., it is neither a hydraulic lime nor a tolerable cement that we have, but a worthless product, which if submerged will remain for days and even weeks without giving any sign of slaking, and then crumble away insensibly without effervescence; or if pulverized and tempered like plaster, will give an appearance of setting, but crack and turn into mud when submerged.

These products, which may be called the intermediate limes, are found on an average between 20 and 23 of clay for 100 of limestone;

but these numbers are not absolute, for some limestones containing 21 and 23 per cent. of clay make both good hydraulic lime and cement, and also the former when underburnt give very irregular results, forming sometimes a cement and at others a worthless compound.

In the same way there is a superior limit to the proportion of clay in cement, which when surpassed gives a poor cement. The exact position of this superior limit is not entirely agreed upon. It is placed at 36 per cent. and sometimes 40 per cent. by Vicat, and at 40 or 46 per cent. by Berthier.

The composition of the layers forming the quarries from which the Rosendale cements are taken is extremely variable, the proportion of clay ranging from 15 per cent. to 47 per cent. Some of these layers contain the right proportion of clay for good hydraulic limes, and for cements, while others contain the proportions which correspond to the intermediate limes and the superior limit of cements. The separate layers are not entirely uniform in their composition, and, like all beds of limestone, those situated near the surface lose a portion of their carbonic acid by the alternate action of heat and moisture.

Therefore, if the stones obtained from the different layers be mixed according to color and physical appearance, as is sometimes practised, and without a due regard to the exact chemical composition of each, it is obvious that uniform and good results are not likely to be obtained.

I am unable to give at present the result of the analysis of more than four of the different brands of Rosendale cement which I have examined, and, the labor being incomplete, I refrain for the present from naming the brands which have been analyzed.

The following are the results:

Analysis of Cement No. 1.

Water,	1·2 per cent.		
Carbonic acid,	traces.		
Silica,	30·7	per ct.,	or as 43·6 per ct. of clay to 56·4 per ct. of lime and magnesia.
Alumina and sesquioxide of iron,	12·0		
Lime,	42·6	per ct.,	
Magnesia,	12·8		
Total,	99·3		

Analysis of Cement No. 2.

Water,	0·2 per cent.
Carbonic acid,	traces.

Silica,	33·	per ct.,	or as 46 per cent. of clay to 54
Alumina and sesquioxide of iron,	13·		
Lime,	33·	per ct.,	per ct. of lime and magnesia.
Magnesia,	20·		
Total,	99·2		

Analysis of Cement No. 3.

Water,	0·5 per cent.		
Carbonic acid,	traces.		
Silica,	27·	per ct.,	or as 37 per cent. of clay to 63
Alumina and sesquioxide of iron,	10·0		
Lime,	50·3	per ct.,	per ct. of lime and magnesia.
Magnesia,	12·		
Total,	99·8		

Analysis of Cement No. 4.

Water,	0·2 per cent.		
Carbonic acid,	traces.		
Silica,	31·6	per ct.,	or as 40 per cent. of clay to 60
Alumina and sesquioxide of iron,	7·8		
Lime and magnesia,	60·	per ct.,	per ct. of lime and magnesia.
Total,	99·6		

These results show that the Rosendale cements above examined contain a proportion of clay which approaches, in some cases, to the proportion indicated by Vicat as forming the best cement, and in others to a proportion nearer the beginning of the scale of cements.

A point worthy of notice is, that if we compare these cements to the English and French cements, the one marked No. 3 contains nearly the same proportion of clay as the French Portland; No. 4 contains the same as the cement of Vassy; Nos. 1 and 2 contain more clay, although nearer the proportions named by Vicat for the best cements, and all contain more magnesia than is common to European cements.

The cements examined also contain traces of alkalies and chlorides. One contained $\frac{7}{1000}$ of sulphate of lime, which is not to be considered injurious, as it does not exceed three per cent.

The large proportion of magnesia in these cements is remarkable.

Chemists are not wholly agreed upon the effects of magnesia in the presence of lime.

Magnesia in the presence of silica and alumina is known to form crystallizations which resist the action of sea water better than lime —and Vicat remarks that the presence of magnesia exalts the quality of cement for marine uses.

On the other hand, it is equally certain that the silicate of magnesia crystallizes slower than the silicate of lime, and Rigot asserts that the consequence of the presence of magnesia is disaggregation, or at least inferior hardness.

In the presence of these conflicting opinions, the true influence of magnesia remains a subject for investigation.

Having but recently analyzed various American limes and cements, I am not able to present comprehensive or complete results, and my object in introducing the subject at this stage is to call the attention and invite the labors of others, in completing the studies required for the uniform production of the best quality of hydraulic limes and cements. But my inquiries have gone far enough to convince me that standard cements will not result from experimental mixtures, not guided by selections based upon accurate analysis.

I conclude with the following analysis of Rockland lump lime:

Water and carbonic acid, . .	traces.	
Silica, ...	5·6	per cent., or 7·8 per cent. clay.
Alumina and sesquioxide of iron,	2·2	
Lime, ...	87·6	per cent., or 91·9 per cent. lime and magnesia.
Magnesia, ...	4·3	
Total, ...	99·7	

Gilding Iron.—The employment of sodium amalgam is recommended by Kirchmann as a simple and effective means of covering iron with a gilded surface. The process, in brief, consists in first spreading the amalgam upon the surface of the metal, which at once coats itself with a layer of quicksilver, even though it may be somewhat rusted. Upon the surface thus prepared a concentrated solution of chloride of gold is poured and the mercury volatilized by heating before the lamp or in a furnace. The result is that a gold surface remains behind which is susceptible of a bright polish. With silver and platinum, it is said, similar results may be obtained.

Franklin Institute.

Proceedings of the Stated Meeting, October 16, 1872.

The meeting came to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The minutes of the last meeting of the Board of Managers, held October 9th, were read by the Actuary, and approved.

The Actuary also submitted the following list of donations to the Library for the month of September, to wit:

A series of Specifications of English Patents for the years 1869, 1870 and 1871, from the Hon. Commissioners of Patents: Annales des Ponts et Chaussées, from the Director of Roads and Bridges, Paris. The American Vine Dresser's Guide, from Alphonse Loubat. The Geological Survey of Ohio, with maps, from J. S. Newbury, State Geologist. A Discussion of the Meteorology of that part of the Atlantic lying north of the 30th parallel (north) for the eleven days ending February 8th, 1870. From the Meteorological Committee of the Royal Society, Wabbs of Venis, prepared for the use of American Ephemeris and the Nautical Almanac. From the Chief of the Bureau of Navigation, Washington, D. C. Proceedings of Academy of Natural Sciences, Philadelphia, from the Society.

The President of the Institute then announced that the evening of the October meeting had been especially set apart for the purpose of discussing the reports of the Committee on the Horse Power of Boilers, but added the following remarks:

It is my painful duty to announce to you this evening the death of a prominent member of this Institute. On Saturday, the 12th inst., Professor JOHN F. FRAZER departed this life, in a sudden, and for aught I know, entirely unexpected manner. Of the sad incidents connected with that event, you are all doubtless familiar, but it is eminently fitting that mention be made at this time of the part played in the history of the Institute by one who has done so much to advance its interests during a period of thirty-seven years. In 1835, Prof. Frazer was elected a member of this Society. From the very first, he was active on committees and in all the scientific investigations undertaken by the Institute; prominently so in all that related to steam boilers and steam boiler explosions. In 1841, he was elected Corresponding Secretary, and was chosen Treasurer in 1848—an office which he held until 1864, a period of sixteen years. Elected Vice-President in 1865, he was forced to resign in 1866, on account of ill health. He was an active member of the Committee on Instructions in 1845,

and Chairman of that important committee until 1866. In 1850, he took formal charge of the JOURNAL of the Institute, and continued to act as its editor until 1866. I feel confident that there are amongst those who hear me this evening, friends of Prof. Frazer, who are much better fitted to speak of his merits than myself—friends who have known him longer and more intimately than I have; but I think there are none who have a higher opinion of his worth, or who regret his death more deeply. From my earliest connection with the Franklin Institute, up to the time when failing health caused him to withdraw from active life, all my recollections of its scientific and practical workship are in some way associated pleasantly with that large-hearted man. Very learned and endowed with an astonishingly retentive memory, he was ever ready to give from his abundant stores of knowledge freely to others. He was ever earnest in his advocacy of right, and ever bold and outspoken in his denunciation of wrong. I saw him on Friday last, seated in the chapel of our great University, taking part in the ceremonies of dedications. I thought of him then as I looked at him, as the oldest member of the distinguished faculty of that old school of learning. It is so sad, so very sad, to think that at the very beginning of a new era in University education in America, so brilliant and useful a member has been taken away.

Upon the conclusion of the President's remarks, Dr. R. E. Rogers, in a few expressive words of deep regret, moved that Mr. Frederick Fraley, who had been so long associated with the deceased in the work of the Institute, be appointed to frame suitable resolutions upon the sad event, expressive of the sentiment of the Society. The motion was carried.

The President then announced the business of the evening to be in order, namely—the discussion of the report of the Committee on the Horse Power of Steam Boilers. The reports were read by the Secretary, and the Chairman of the Committee inaugurated the discussion by some lengthy remarks, defining the origin of the Committee, its labors, and advocating the adoption of some standard of rotary boilers by the Institute. He was followed by Mr. Robert Briggs, and the discussion finally was participated in by Prof. R. E. Rogers, Wm. B. Le Van, Lovegrove, S. L. Wiegand and other members, and will be found in full in the Journal of the Franklin Institute, vol. lxiv, page 377.

The Secretary next read a brief report upon Current News, and the meeting was, upon motion, adjourned.

W. H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, Nov. 20th, 1872.

The meeting was called to order by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at their Stated Meeting, held November 13th, the following donations had been received into the Library:

The thirty-ninth Annual Report of the Royal Cornwall Polytechnic Society, 1871, from the Society. From a member, Recent Practice in the Locomotive Engine: being a supplement to Railway Machinery, by Daniel Kennea and Zerah Colburn. From the Hon. Secretary of the Navy, papers relating to the Transit of Venus in 1874. From the American Philosophical Society, their proceedings from January to June, 1872. From the Zoological Society of London, their proceedings for 1872, with a Catalogue of their Library. From the Academy of Sciences of Paris, "Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences," from April to July, 1872. From the Institute of Civil Engineers of London, England, "Minutes of Proceedings," Vols. 33 and 34. From the Chemical Society of London, their Journal for May, June and July, 1872. From the Society of Arts, of London, 9 vols. of their Journal, from Aug. 2d, 1872, to Sept. 27th. From the Statistical Society of London, Vol. 35, Part 3d, of their Journal. From the Society for the Encouragement of National Industry, of Paris, their "Bulletin" for August and September, 1872. From the Academy of Sciences, Comptes Rendus Hebdomadaires des Seances, from July to September, 1872. From the Literary and Historical Society of Quebec, their Transactions of the Session of 1871–72. From the Academy of Natural Sciences, of Philadelphia, Part 2nd of their Proceedings, from May to September, 1872.

Mr. Frederick Fraley then, upon request, presented the following Resolutions upon the death of Prof. J. F. Frazer, which were unanimously adopted:

Resolved, That the Franklin Institute, in recording upon its minutes the sudden and lamented death of JOHN F. FRAZER, LL. D., is called upon by a high obligation of duty to acknowledge the manifold services he rendered as a member, officer and professor, and to express its sense of his character and worth as a citizen and friend.

Resolved, That it is with great pride we feel that we can claim him as a scientific man, made so to a great extent by the Institute, to which he attached himself in early life, and by his hearty co-operation in the labors of its founders and friends, greatly aided in raising it to the high rank which it now enjoys.

Resolved, That the services of Prof. Frazer in the Chair of Chemistry, as Editor of the JOURNAL, as a member of many important committees on science

and the arts, and as a liberal and devoted friend, always ready with heart, head and purse, to promote the interests, welfare and reputation of the Institute, will ever be held in grateful remembrance by its members.

Resolved, That it is with deep sorrow we mourn the loss of one who has filled so important a part in the history of the Institute, but trust that his example may have many followers, and that, emulating his manly, chivalric and ingenuous career, they may love it as he did, and faithfully and fearlessly carry forward all its aims for the promotion of the mechanic arts, and technical education.

Resolved, That we sincerely sympathize with his family in their great bereavment, and that the President of the Institute be requested to forward to them a copy of these resolutions as our tribute of love and respect for one so worthily endeared to them.

The President next announced, in appropriate terms, the death of Mr. John Agnew, dwelling upon his life-long connection with the Institute, and requested Mr. Frederick Fraley, who had been associated with the deceased in the working of the Institute longer than any other member, to address the Institute in relation to the character and services of Mr. Agnew. Mr. Fraley responded with a lengthy, extemporaneous eulogy of the deceased, which he was requested to prepare suitably for entrance on the minutes of the Society.

The President next announced a description by Mr. J. E. Mitchell of a new tool for turning and dressing grindstones.

Mr. Mitchell was followed by Mr. G. M. Eldridge with a paper on a new device for securing circulation in steam boilers, &c., in which it is asserted that with a model constructed for the purpose of experiment, the evaporation had been increased 50 per cent.

Mr. Hector Orr next presented a paper on the premature decay of timber, which was suggested by an examination of the wreck of the steam frigate Chatanooga. The paper elicited an extended discussion, which was participated in by Messrs. Close, Fraley, Sellers, Durfees, Eldridge and Orr, and is published in the Journal of the Institute, Vol. lxv, page 55.

The President next announced the addition of the following named gentlemen upon the committee to determine the mode of estimating the horse power of steam boilers, viz: Lloyd S. Wiegand, Prof. R. E. Rogers, and Thomas L. Souders.

The meeting was then, upon motion, adjourned.

W. H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, Dec. 18, 1872.

The meeting was called to order by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their Stated Meeting, on December 11th, the following donations to the Library had been received.

From Prof. J. H. C. Coffin, U. S. N., The American Ephemeris, and Nautical Almanac for the year 1873. From the Chemical Society, of London, their Journal for August, September and October, 1872. From the Society of Arts, of London, their Journal for October, 1872.

The Secretary next read, at request of the President, the following resolutions of respect to the memory of the late Vice-President of the Society, Mr. John Agnew, prepared and offered for approval by Mr. Frederick Fraley, which were unanimously adopted:

Resolved, That the members of the Franklin Institute, affectionately cherishing the long and faithful services of JOHN AGNEW as a member and officer of the Institution, desire to place permanently on its records their high appreciation of his worth and virtues.

Resolved, That the example furnished to our mechanics and workingmen of all classes by the long and useful life of Mr. Agnew, is one eminently worthy of imitation, and has been of great utility to the Institute, and the public generally, showing how much may be accomplished by earnestness and zeal, unaided by early advantages of education, social position, or wealth.

Resolved, That it is a source of great pleasure and thankfulness on the part of the members of the Institute that, during the whole course of a life protracted beyond the ordinary limits allotted to many, John Agnew was permitted to give his time and talents to the promotion of the great objects of the Franklin Institute by associating himself with it as an original member, and for nearly half a century devoting himself and his energies to its success and welfare.

Resolved, That while we sincerely condole with his widow and his friends generally in the bereavement caused by his death, our regret for his loss is softened into rejoicing by the conviction that his quiet translation from earth has been to a final resting place of eternal rest and happiness.

Resolved, That the President be requested to transmit a copy of these resolutions to the widow of Mr. Agnew.

The President next announced the paper for the evening to be by Mr. Samuel Webber, on the construction and use of the "Francis' Dynamometer." The paper attracted considerable discussion, which was participated in by Messrs. Nystrom, Webber and the President, and will be found published in full in the Journal of the Institute for February, 1873.